

STATIONARY SOURCE TEST OBSERVATIONS

**Compliance Assistance Program
California Environmental Protection Agency
Air Resources Board**

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100 INTRODUCTION

Stationary Source Test Observations

The California Environmental Protection Agency (Cal/EPA) was created in 1991 to bring together, under a single accountable agency, the following State of California environmental entities: the Department of Pesticide Regulation, the Department of Toxic Substances Control, the Office of Environmental Health and Hazard Assessment, the Integrated Waste Management Board, the State Water Resources Control Board, nine Regional Water Quality Control Boards, and the Air Resources Board.

The Air Resources Board (ARB) establishes and enforces standards to limit pollutant emissions from motor vehicles. Additionally, the ARB does the following:

1. Conducts inspections, in cooperation with local air pollution control districts (APCD), to ensure compliance with air pollution regulations by applying consistent and evenhanded enforcement.
2. Develops suggested rules and regulations to assist local APCDs in their efforts to improve air quality.
3. Establishes air quality standards to protect the health of the most vulnerable members of the population and to prevent damage to crops and property.
4. Evaluates the effectiveness of pollutant control strategies for vehicles and industrial sources.
5. Monitors air quality throughout the state.
6. Conducts extensive research programs.
7. Conducts and audits stationary source testing projects, in cooperation with local APCDs.

The ARB's past efforts have significantly reduced the pollution emitted from vehicles and large stationary industrial sources. However, successfully regulating a very large number of small, diverse stationary sources poses even greater challenges than previous clean air measures. Continuing to improve the air quality requires hard work and careful planning.

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101 COMPLIANCE ASSISTANCE PROGRAM

The Compliance Assistance Program (CAP), created in 1988 by the ARB, assists local air districts in conducting more comprehensive, consistent and accurate facility compliance inspections. The CAP also provides industry with information and tools, in the form of self-help publications, which clarify compliance requirements and help explain how to stay in compliance with air pollution rules and regulations. CAP also assists industry in establishing their own compliance inspection programs. By conducting routine compliance inspections, facilities can stay in compliance on a daily basis and can thereby avoid costly air pollution violations.

Enforcement audits of some industrial sources have shown noncompliance rates as high as 50 percent. Improving these rates can bring rewards to everyone.

Based on the idea that sources will comply if the source operators understand what is required of them, CAP identifies requirements of regulations and presents them in several readily-understandable formats. These CAP publications can assist industries in monitoring emissions and conducting inspections, thereby increasing their compliance rates, and reducing costly violations. Through the development and distribution of these publications, CAP creates a flow of information in a variety of useful formats:

Handbooks: Easy-to-read, colorfully illustrated handbooks are developed for the industrial labor force. Most can be read in 10 minutes or less, and all contain helpful self-inspection checklists.

Pamphlets: Quick-reference pamphlets contain detailed flow charts, checklists and helpful diagrams. These are designed for facility managers and industry's environmental managers.

Technical Manuals: Detailed technical manuals are developed for industry environmental managers, ARB inspectors and local APCD inspectors. These contain rule information, process descriptions, and step-by-step procedures for compliance inspections, including checklists.

102 MANUAL PURPOSE AND USE

This manual is designed to assist industry, environmental managers, local APCD inspectors, and ARB personnel in conducting and/or observing or auditing stationary

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Stationary Source Test Observations

source pollutant emissions sampling programs. Sampling stationary sources for pollutant emissions is commonly referred to as "Source Testing" or "Stack Testing", which is the subject of this technical manual.

103 MANUAL DESIGN AND ORGANIZATION

This manual is organized into five main sections, as follows:

1. Section 100 - Introduction:
This is the section currently being read. It presents a brief overview of the function of the ARB and its Compliance Assistance Program, and outlines the purpose of this manual, its organization, and steps for maintaining it.
2. Section 200 - Background:
This section begins with a brief description of the sources of air pollution, and the resulting needs or purposes for stationary source testing. Applicable local, state and federal rules and regulations are also presented.
3. Section 300 - Source Testing Fundamentals:
This section presents, in brief, some of the more important basic scientific principles applicable to the successful collection of representative stack samples. This is not a rigorous discussion, but an overview of several fundamental concepts from the fields of chemistry, physics and fluid mechanics which are important in understanding the dynamics of gaseous flow and particulate behavior. This enables one to more fully understand and appreciate source sampling procedures, equipment selection, and sample recovery and analyses.
4. Section 400 - Source Test Methods Review:
This chapter contains summaries of the more common U.S. EPA and ARB source test methods used, and a section on continuous emissions monitors and analyzers. Complete lists of all ARB and U.S. EPA stationary source test methods are provided in Appendix B.
5. Section 500 - Performing/Observing the Source Test:
This section presents information regarding how to conduct a stationary source test, from project inception and planning, through its completion with the source test report. This is based on a "Method 5" source test for

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particulate matter for several reasons. Built into a Method 5 source test, either directly or by reference, are the procedures and equipment specifications necessary to determine proper stack sampling points/traverses (Method 1), stack gas velocity and flow rate (Method 2), gas analysis and molecular weight (Methods 3 and/or CARB Method 100), moisture content (Method 4), and finally, particulate matter and report writing. Also, most other source test methods, especially for determining emissions of toxic air contaminants, are based on Method 5 and are, in fact, referred to as "Modified Method 5" procedures. Understanding how to perform or observe/audit a Method 5 test is the best foundation for learning how to perform or observe most other source test methods, from metals to dioxins.

6. **Section 600 - Real World Source Testing:**
This section discusses some of the more common situations and problems encountered when performing a source test. Troubleshooting a difficult source test is covered in this chapter. Emission data alterations and calculation tips are discussed. Problem sources with unusual sampling locations, as well as single-point and bag sampling techniques, are reviewed. The last section goes over some of the newer trends in source testing such as fourier transform infrared spectrographic (FTIR) emissions monitoring, Auto 5", and others.

104 MANUAL MAINTENANCE

This manual is intended to be a dynamic reference document. To keep this manual accurate and current, CAP staff rely on district staff, industry personnel and other users for their expertise. As changes, additions, and improvement issues concerning this technical manual are raised, users should make note of them. All comments should be forwarded to:

**Air Resources Board
Compliance Division
Compliance Assistance Program
P.O. Box 2815
Sacramento, CA 95812**

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Comments are reviewed as they are received and if any proposed amendments need immediate attention, changes will be made as soon as possible. A draft of the revised technical manual will then be provided for comment to all local districts. For proposed changes which are deemed minor or not technically significant, several will be accumulated before any changes are made. If regulations change significantly or new information regarding source testing is made available, a technical manual update package will be prepared and sent to all users who have completed and returned a Manual Tracking Card.

A Manual Tracking Card is located at the front of this manual. It is important that each recipient of one of these manuals complete and return a card to the address listed previously. Technical manual upgrade packages will only be sent to those who have completed and returned this card.

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Stationary Source Test Observations

The purpose of this technical manual is to provide information on stationary source test observations for industry, air pollution control/air quality management districts, and environmental consultant personnel. It is designed to provide air pollution and environmental professionals a basis for understanding and successfully observing/auditing a source test from its inception through protocol development, laboratory and equipment preparation, the source test itself, including data collection and management, and data analysis and reporting. It is not designed, however, to provide comprehensive information or step-by-step procedures detailing all of the intricacies and subtleties of performing source testing.

While the purposes for conducting source testing vary, the ultimate goal is the same. A source test is conducted to determine, as accurately as possible, the rate at which a specific air pollutant is emitted into the atmosphere from a particular process, point or "source." Source testing personnel must be well-trained and have adequate hands-on experience to successfully conduct a source test. Simply reading and becoming familiar with several applicable source test procedures will not enable a person to perform a source test. Source test projects are usually managed by professionals educated in engineering or the sciences, and having significant experience in performing a variety of source test procedures.

There are hundreds of source test procedures which have been adopted by the United States Environmental Protection Agency (U.S. EPA), the California Air Resources Board (CARB), various California air pollution control and air quality management districts, and other governmental agencies. These procedures do not provide enough information, in themselves, for the source testing professional to accurately determine the emission rates of various pollutants from any stationary source. Specific information about a particular source must be determined prior to selecting appropriate test methods, test equipment and analytical methods.

For some sources, an appropriate test method may not exist, but a method may have to be developed by the source tester, along with input and approval of source personnel and various governmental agencies. Source test development can be complicated and must incorporate sound engineering judgement and experience as well as excellent communication with all concerned parties.

This manual provides general information on source testing, from the fundamental sciences on which basic source testing methods are built, to a presentation and

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explanation of the most commonly-used methods, and a guide enabling the source test auditor or observer to successfully document and observe a source test.

This chapter includes an overview of health effects, anthropogenic sources of air pollution, purposes for conducting a source test, programs requiring a source test, and the rules and regulations for stationary source testing in California. Later chapters provide more specific information on conducting a source test and auditing or observing a source test.

201 HEALTH EFFECTS

The release of harmful emissions into the atmosphere effect our health and welfare. Exposure to hazardous environmental pollution can cause damage to numerous body systems, including gastrointestinal, integumentary, cardiovascular, skeletal, circulatory, and the central nervous system. In addition, pollution can cause harm to agriculture, animals, and plants. Particulates, oxides of nitrogen, oxides of sulfur, lead, carbon monoxide, volatile organic compounds, and other toxic pollutants are responsible for numerous health conditions, and therefore, the amount of these emissions released from stationary source stacks is monitored. Although dose and exposure duration is a factor, increased or prolonged exposure to harmful emissions such as VOCs, particulates, SO_x , NO_x and CO can exacerbate preexisting conditions of asthma, allergies, chronic obstructive pulmonary disease (COPD), and coronary artery disease.

201.1 PARTICULATE MATTER

Particulate matter is finely divided solid or liquid material found in a flue gas. This matter may be more commonly known as a fume, mist, smoke, or spray. High concentrations of particles in the atmosphere can cause respiratory illness, obscure visibility, damage material and agriculture, and affect our psychological well-being.

The size of particles released into the atmosphere has great implications with regard to human health. Research has shown that it is those particles 10 microns (μ) or less in aerodynamic diameter (PM10) that are the most harmful to human health. Particles that are greater than 10μ in diameter tend to collect in the upper part of the respiratory system where they collect moisture as they move through the upper respiratory region. Eventually these larger particles are removed by sneezing, coughing or swallowing.

Particles in the range of 1 to 10μ in diameter tend to collect in the middle part of the respiratory system, or the tracheobronchial region. Particles in the range of 1μ in

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diameter tend to deposit in locations where the bronchi of the lungs begin to branch off into the smaller bronchioles. The particles impact the walls of the bronchi when they are unable to make the turn into the bronchioles. The smaller submicron size particles, less than 1μ in diameter, can make the turn and penetrate down into the air sacs, or alveoli, the area where oxygen is transferred to the blood.

Recent U.S. studies indicate that hospital admissions and mortality are directly associated with higher levels of ambient particle exposure in some American cities. The studies are consistent with a 1% increase in all related hospital admissions and mortality with a $10\text{mg}/\text{m}^3$ rise in PM_{10} . When this data is broken down by disease, the effect is greatest for patients with preexisting lung disease, particularly chronic bronchitis and emphysema or COPD, where the increase may be as great as 3 percent.

201.2 VOLATILE ORGANIC COMPOUND (VOC)

Volatile organic compounds are found in many common products, including paints and coatings, cleaning products and deodorants. In the United States, motor vehicles account for approximately half of VOCs emitted into the atmosphere. VOCs can be hazardous air pollutants (HAPs), or in the air, they react with oxides of nitrogen and sunlight to form ozone, a proven health hazard. The volatility of VOCs makes them primarily an air problem, with inhalation the primary route of exposure for humans. Therefore, controlling the release of VOCs into the atmosphere is an effective method for minimizing ozone levels, and the associated health problems. Ground level ozone, a highly reactive gas, affects the normal function of the lungs. Exposure to high concentrations of ozone for several hours induces respiratory inflammation and decreased lung function. In addition, many VOCs have been known to cause cancer in people and in animals. EPA California projects have estimated 100 to 1,000 cancer cases per year attributable to mobile sources of air pollution.

201.3 OZONE

Ozone, a colorless gas, is the chief component of smog. It is one of California's most persistent and widespread air quality problems. Ozone is formed when VOCs and nitrogen oxides emitted from motor vehicles and industrial sources, react in the presence of sunlight.

Ozone is a strong irritant which can cause constriction of the airways, and force the respiratory system to work harder to provide oxygen. Short term ozone exposure for one or two hours can cause shortness of breath, and aggravate pre-existing respira-

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tory diseases such as emphysema, bronchitis, asthma, and heart disease. Chronic or long term exposure can permanently damage the alveoli, or the lung tissue where the oxygen and carbon dioxide are exchanged. Children and the elderly are particularly susceptible to ozone exposure.

Ozone can also damage crops and vegetation by stunting growth, damaging leaves, and by reducing crop yield and market value. The damage ozone causes to crops can increase susceptibility to disease and insect attack.

201.4 SULFUR OXIDES (SO_x)

Sulfur oxides are gases that are formed when fuel containing sulfur (mainly coal and oil) is burned, during metal smelting, from refineries, and from pulp and paper processing mills. Sulfur dioxide and other oxides of sulfur combine with oxygen to form sulfates and with water vapor to form aerosols of sulfurous and sulfuric acid. Exposure to high concentrations of SO_2 causes breathing problems, respiratory illness, and aggravations of existing cardiovascular disease. The populations most severely affected are children, the elderly, asthmatics, and individuals with bronchitis or emphysema. Damage to trees, agriculture and animals also occurs.

201.5 OXIDES OF NITROGEN (NO_x)

Nitrogen oxides are gases that are formed from the combustion, at high temperature and pressure, of fossil fuels. Nitric oxide (NO) and nitrogen dioxide (NO_2) are the main contributors to direct air pollution emissions. NO_x is produced from the combustion of petroleum products by motor vehicles, electricity generating stations, kraft and pulp paper mills, wood burning, waste incineration, oil refining and gas production, cement processing, ethanol production, and steel and iron industries. NO_x may combine with water in the air to produce acid rain, and, when combined with hydrocarbons in the presence of sunlight, can contribute to the formation of ground-level ozone pollution. NO_x can irritate the lungs and lower resistance to respiratory infection. It can corrode metals, degrade rubber, and damage vegetation.

201.6 CARBON MONOXIDE (CO)

Carbon monoxide is a colorless, odorless, and poisonous gas, produced by the incomplete combustion of carbon in fuels. Approximately 60 percent of the nationwide CO emissions are from transportation sources; the largest contribution coming from highway motor vehicles. The mechanism of action in the human body for carbon

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monoxide is that it enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. For those who suffer from cardiovascular disease, specifically angina and PVD (Peripheral Vascular Disease), the threat is the most serious.

202 ANTHROPOGENIC SOURCES OF AIR POLLUTION

Air pollution refers to the presence of undesirable material in the air in quantities large enough to produce, or to potentially produce, harmful effects to human health, property, vegetation, animals or the global environment. These harmful effects include aesthetic degradation such as reduced visibility and unpleasant odors. Anthropogenic sources of air pollution are those which are generated or produced by man or human kind ("anthropo-" meaning man or human, and "-genic" meaning origin or genesis).

Mankind does not control or produce "natural" sources of air pollutants, such as those generated by volcanos, or produced by wind and weather, plants and animals. Of course, windblown dust can be produced, in part, as a consequence of human activities such as agriculture, mining and building. And greenhouse gases such as carbon dioxide and methane are emitted, in part, by plants and animals cultivated and bred for human consumption.

Anthropogenic sources include (1) Mobile Sources, (2) Fugitive Sources, and (3) Stationary Sources, which are defined in the next section. This manual, however, applies only to emissions testing of stationary sources.

202.1 MOBILE SOURCES

Mobile sources are defined as all things that move and emit air pollutants. In California, a large share of ozone and particulate matter air pollution is emitted by highway vehicles, aircraft, ships, locomotives, construction equipment, and similar sources. Because of the decentralized type of emissions produced by mobile sources, air pollution from these sources is far more difficult to control and regulate than emissions produced at stationary sources. Motor vehicles emit all of the primary pollutants, but of more concern are carbon monoxide (CO), nitrogen oxides (NO_x), and volatile organic compounds (VOCs). A key element of California's plan for attaining health based air quality standards are zero and near-zero emission vehicles (ZEVs).

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202.2 FUGITIVE SOURCES

Fugitive sources include emissions generated by human activities such as agricultural and mining activities, road and structural building, solid waste landfills and animal farming. These tend to be considered "area" sources, not specific, or clearly identifiable "point" sources.

Included in the definition of fugitive sources are emissions from industrial process areas which are not clearly defined, or are not emitted from a fixed point such as an exhaust stack or duct. Examples of these types of fugitive emissions include particulate emissions from materials handling/conveying, transfer points and storage devices. Emissions of particulates, fumes, and gases from processes such as welding operations, electroplating, grinding and sanding operations are also examples of fugitive emissions.

Fugitive sources will not be further addressed in this manual, although, if these emissions are directed to an exhaust stack or duct, the source test principles would be applicable. It must also be recognized that the collection efficiency of the hood/fugitive emissions collection device must be considered when determining total emissions.

202.3 STATIONARY SOURCES

Virtually any source of pollutants that is not considered a mobile, area, or fugitive source, is a stationary source, or point source. Stationary sources are characterized as commercial, industrial or utility processes which emit gaseous or particulate (solids and aerosols) pollutants. These processes are often combustion processes; i.e., they burn some type of homogeneous or heterogeneous gaseous, liquid or solid fuel to provide on-site power, utility power, process steam, or destroy waste materials. Whether a stationary source is a combustion process or some other industrial process, it exhausts products of combustion, undesirable components, or waste products through an enclosed duct or stack into the atmosphere. Often, the exhaust is routed through an air pollution control device(s) for treatment and recovery of pollutants prior to venting to the atmosphere.

Stationary source testing is performed to determine the type and quantity of a particular pollutant(s) emitted to the atmosphere from a specified process by performing stack testing. Source or "stack" testing can also be performed both at the

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air pollution control unit inlet and at the outlet, or stack, to determine the unit control efficiency.

Source testing can be performed, using specialized procedures, on gasoline vapor recovery systems. Procedures sharing some of the principles of source testing can be utilized to estimate emissions from landfills. These principles, combined with ambient air monitoring techniques, can also be used to perform source-impacted ambient air studies. These procedures are not addressed in this manual.

203 PURPOSES FOR SOURCE TESTING

The purpose of a source test is to accurately determine the quantity of the total source exhaust or stack flow rate and to determine the quantities or mass emission rates of specific air pollutants emitted. Source or stack testing/sampling is performed because it is the most sensitive and accurate method of reaching this objective for a specific, unique source. The purposes for performing a source test are varied and directly impact test parameters, such as: equipment needs, laboratory arrangements, test preparation, test personnel, permit requirements, air district participation, and costs.

Other methods, such as emission factors, material balances and combustion calculations are only estimates. Emission factors are generally industry-wide averages for a particular type of process and fuel/feedstock. The data accumulated to calculate average emission factors is likely to have come from processes of different designs and sizes, and the methods used to obtain the data may vary. Material balances and combustion/stoichiometric calculations are good for determining average stack flow rates for steady processes with consistent, homogeneous fuel/feedstocks, but cannot accurately estimate pollutant concentrations.

203.1 AGENCY REQUEST FOR DATA

Many rules and regulations now exist that allow and encourage agency presence at a source test or for the agency to require a source test. For the regulatory agency, accurate test results provide the necessary data to evaluate compliance with regulations and emission limits. Compliance determination is the most common use of source tests and their results, although several other uses can be made of the results, which, on their own, could justify performing the source tests.

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203.2 COMPLIANCE

Stationary source testing is the most reliable way to learn, with certainty, the compliance status of a stationary source. Source testing physically measures the emissions, in contrast to other engineering methods, which may only estimate emissions. The results of source testing are used primarily to verify compliance status with local, state, and federal air pollution regulations, and so is the preferred method of regulatory agencies.

203.3 ENGINEERING EVALUATION

In addition to performing source testing for compliance status and to comply with a regulatory request, source testing is also used for engineering evaluation purposes. The choice of appropriate collection systems, collection media and the analytical method for a given source, is extremely important and dependent upon the primary reason for initiating the source sampling. The main reasons for performing engineering evaluations are listed below.

203.3.1 Process Optimization

Source test results can be utilized by the source to improve their process operation. Test results can provide information on the efficiency of the process in terms of raw material usage or energy efficiency. Specifically, in some cases, the test results can pinpoint operations that are wasting materials or venting unnecessarily into the atmosphere. Often a test can provide energy use information that can be used to fine tune a combustion process; it is not uncommon, especially for turbines and engines, to see a significant fuel savings by incorporating test results into operational procedures.

203.3.2 Control Device Efficiency

Control device efficiency and improving air pollutant emission control at a lower cost, are two ways in which source test results can be helpful. Source testing can be a useful tool when designing new facilities or modifying existing facilities. When designing process units, process operation improvement and efficiency can be gained by the input of source test data. Source test data can be used to meet process requirements for new and modified sources.

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204 PROGRAMS REQUIRING SOURCE TESTING

Many programs require source testing to monitor emissions in California. An increasing number of programs covering new sources and categories may be federal, federal programs delegated to the states, federal mandates to the state, state, district or local rule.

204.1 NSPS

The Federal New Source Performance Standards (40 CFR 60) program provisions require an initial performance test to be performed within sixty (60) days, but no longer than 180 days, after achieving the maximum production rate at which the affected facility will be operated. Subsequent source tests may be required whereby the owner or operator of the facility must conduct performance tests and provide a written report of the results of the test. Provisions also require that sufficient notice be given so that an observer may be present. **Table 204.1** lists NSPS source categories by letter designation.

204.2 NESHAPS

The Federal National Emissions Standards for Hazardous Air Pollutants (40 CFR 61) is a technology based program to limit the emissions of 188 hazardous air pollutants (HAPs). In response to this program, the California Legislature enacted AB 2728 in 1993, which integrated the federal air toxics program with regard to HAPs and MACTs with California's toxic air contaminant (TAC) Identification and Control Program. Consequently, in California, HAPs, are referred to as toxic air contaminants TACs. To implement the program, maximum achievable control technology (MACT) standards are developed on a source category basis. MACT emission standards adopted by U.S. EPA for source categories and subcategories automatically become air toxic control measures (ATCMs) in California on the effective date of the MACT when California has no corresponding ATCM for the source category. When California does have a corresponding ATCM for the source category, both the State ATCM and the federal MACT are enforceable - the State ATCM by the local air districts and the MACT by the US EPA. The NESHAPs program requires an initial source test and a source test at other times. **Table 204.2** lists NESHAP categories by letter designation.

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Table 204.1 - New Source Performance Standards (NSPS)

Subpart Letter	Source Category
D	Fossil-Fuel Fired Steam Generators (Built after 8/17/71)
Da	Electric Utility Steam Generating Units (Built after 9/18/78)
Db	Industrial-Commercial-Institutional Steam Generating Units
Dc	Small Industrial-Commercial-Institutional Steam Generating Units
E	Incinerators
Ea	Municipal Waste Combustors (Built after 12/20/89)
F	Portland Cement Plants
G	Nitric Acid Plants
H	Sulfuric Acid Plants
I	Asphalt Concrete Plants
J	Petroleum Refineries
K	Storage Vessels for Petroleum Liquids (Constructed after 6/11/73)
Ka	Storage Liquids for Petroleum Liquids (Constructed after 5/18/78)
Kb	Storage Vessels for VOCs (post 7/23/84)
L	Secondary Lead Smelters
M	Secondary Brass and Bronze Ingot Production
N	Primary Emissions from Basic Oxygen Process Furnaces (post 6/11/73)
Na	Secondary Emissions from Basic Oxygen Process Furnaces (post 1/20/83)
O	Sewage Treatment Plants
P	Primary Copper Smelters
Q	Primary Zinc Smelters

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Table 204.1 - New Source Performance Standards (NSPS), (cont'd)

Subpart Letter	Source Category
R	Primary Lead Smelters
S	Primary Aluminum Reduction Plants
T	Phosphate Fertilizer Industry: Wet Process Phosphoric Acid Plants
U	Phosphate Fertilizer Industry: Superphosphoric Acid Plants
V	Phosphate Fertilizer Industry: Diammonium Phosphate Plants
W	Phosphate Fertilizer Industry: Triple Superphosphate Plants
X	Phosphate Fertilizer Industry: Granular Triple Superphosphate Plants
Y	Coal Preparation Plants
Z	Ferroalloy Production Facilities
AA	Steel Plants - Electric Arc Furnaces
AAa	Steel Plants - Electric Arc Furnaces, Argon-Oxygen Decarburization Vessels (post 8/17/83)
BB	Kraft Pulp Mills
CC	Glass Manufacturing Plants
DD	Grain Elevators
EE	Surface Coating of Metal Furniture
GG	Stationary Gas Turbines
HH	Lime Plants
KK	Lead-Acid Battery Manufacture Plants
LL	Metallic Mineral Processing Plants
MM	Automobile and Light-Duty Truck Surface Coating Operations
NN	Industrial Surface Coating: Large Appliances
PP	Ammonium Sulfate Manufacture Plants
QQ	Graphic Art Industry Publication Rotogravure Printing
RR	Pressure Sensitive Tape and Label Surface Coating Operations

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Table 204.1 - New Source Performance Standards (NSPS), (cont'd)

Subpart Letter	New Source performance Standards (NSPS)
SS	Industrial Surface Coating: Large Appliances
TT	Metal Coil Surface Coating
UU	Asphalt Processing and Asphalt Roofing Manufacture
VV	Equipment Leaks of Volatile Organic Compounds (VOC) in Synthetic Organic Chemical manufacturing Industry
WW	Beverage Can Surface Coating Industry
XX	Bulk Gasoline Terminals
AAA	New Residential Wood Heaters
BBB	Rubber Tire Manufacturing
DDD	Polymer Manufacturing
FFF	Flexible Vinyl and Urethane Coating and Printing
GGG	Equipment Leaks of VOC in Petroleum Refineries
HHH	Synthetic Fiber Production Facilities
III	Synthetic Organic Chemical Manufacturing Industry (SOCMI) Air Oxidation Units
JJJ	Petroleum Dry Cleaners
KKK	Equipment Leaks of VOC from Onshore Natural Gas Processing Plants
LLL	Onshore Natural Gas Processing Plants: SO ₂ Emissions
NNN	SOCMI Distillation Operations
OOO	Nonmetallic Mineral Processing Plants
PPP	Wool Fiberglass Insulation Manufacturing Plants
QQQ	Petroleum Refinery Wastewater Systems
SSS	Magnetic Tape Coating Facilities
TTT	Surface Coating Plastic Business Machine Parts
UUU	Calciners and Dryers in Mineral Industries
VVV	Polymeric Coating of Supporting Substrates

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204.3 ACID DEPOSITION

The Acid Rain Program was established by the U.S. EPA under the authority of Title IV of the Clean Air Act Amendments (CAAA) of 1990. By setting emission limits, the program can reduce precursor emissions, thereby preventing the adverse effects of acidic deposition. The Acid Rain Program regulations apply to fossil fuel fired electric utility boilers and turbines, controls the emissions of SO₂, NO_x, CO₂, and opacity and allows for the trading of SO₂ emission credits. Stack gas velocity, mass emission data,

Table 204.2 - NESHAP Subparts

NESHAP Subpart	Affected Facility	Monitor Required	Averaging Period	Compliance Method
C	Extraction plants, ceramic plants, foundries, incinerators, and propellant plants which process beryllium ore, beryllium, beryllium oxide, beryllium alloys, or beryllium-containing waste. Machine shops which process beryllium, beryllium oxides or any alloy containing more than 5 percent by weight.	Beryllium	24 Hours	Method 103 Method 104
D	Rocket motor test sites	Beryllium	2 Weeks	Method 103 Method 104
E	Stationary sources which process mercury ore to recover mercury	Mercury Ore	24 Hours	
F	Ethylene Dichloride purification Oxychlorination reaction Vinyl chloride plant PVC reactor Mixing, weighing and holding containers Control systems to which reactions and Fugitive emissions are ducted	Vinyl Chloride	3 Hour	Method 106
N	Glass melting furnace opacity	Opacity	6 minute	Method 108
O	Copper converter	Opacity	1 Hour	Method 9
R	Phosphogypsum stack (inactive)	Radon-222	Within 60 days from inactive status	Method 115
V	Equipment Leaks	VHAP	Monthly	Method 21 Method 22
BB	Benzene loaded tank trucks, railcars, marine vessels at each benzene production facility and each bulk terminal	Benzene	6 Hours	Method 25A Method 25B

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oxygen, carbon dioxide, and pollutant concentration must be monitored in order to determine SO₂ and NO₂ emissions.

204.4 STATE IMPLEMENTATION PLAN MONITORING

Each state is required to submit a State Implementation Plan (SIP) to the U.S. EPA for approval. The SIP establishes a plan to attain, maintain, and enforce the National Ambient Air Quality Standards (NAAQS) for each air quality control region in the state. Section 51.212 of 40 CFR 51 stipulates that the plan must provide for periodic testing and inspection of stationary sources, enforceable test methods for each emission limit specified in the plan, and a system for detecting violations of any rules and regulations through the enforcement of appropriate visible emissions limitations and for investigating complaints. Appendix M of Part 51 lists the recommended test methods for SIPs. Appendix A of 40 CFR 60 lists appropriate test methods.

204.5 PERMITS

In California, operating permits are issued to sources by each of the 35 air districts. The ARB "Criteria for Assessing District Enforcement and Permitting Program Adequacy" requires that the districts incorporate source testing into their permits and programs. Permits issued dictate all operating and testing procedures for that particular source. District permit monitoring provisions can be more strict than the regulatory requirements.

204.6 RCRA HAZARDOUS WASTE INCINERATION

The Resource Conservation and Recovery Act (RCRA) has several requirements for monitoring emissions from facilities burning hazardous wastes. Hazardous wastes can either be burned in incinerators, or in boilers and industrial furnaces (BIF). Because carbon monoxide emissions are used as an indicator of combustion process efficiency, CO monitoring is required of all hazardous waste combustors. Burning by incineration requires velocity measurement of the stack gas and concentration of carbon monoxide. When boilers and industrial furnaces are used to burn hazardous waste, CO, O₂ and hydrocarbon monitoring is required. As new technologies for monitoring stack gases are developed, additional permit provisions may require appropriate emission testing and/or monitoring. RCRA sources are required to conduct intensive reference

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Table 204.3 RCRA Monitoring Requirements

Subpart	Source Category	Source Facility	Measurement
264	Hazardous Waste Incinerators	Incinerators	CO Velocity
266	Boilers and Industrial Furnaces Burning Hazardous Wastes (BIF Rules)	Boiler, Furnace, or Kiln	CO O2 THC

method testing that monitors excess emissions of toxic compounds, chlorinated compounds, and metals, etc. **Table 204.3** lists RCRA monitoring programs.

204.7 DISCRETIONARY MONITORING PROGRAMS

Discretionary stationary source testing programs can include:

- **Variances** - Under special circumstances a temporary authorization (variance) to emit may allow a source to discharge pollutants in excess of the level allowed by the standard that otherwise may apply. Usually a variance is issued for a specific time period, provided the source corrects the problem and meets the standard by the end of the variance period. The specific details of the variance issued can sometimes include special monitoring requirements. Variances provide temporary relief from state and local government enforcement actions, but not from federal enforcement and regulations.
- **Orders** - Orders and legal directives are generally issued after a public hearing is conducted. Section 113 of the Clean Air Act gives authority to enforce orders to be issued to a source requiring them to comply with state agency requirements. The type of legal authority that issues the order determines whether it is an administrative order, delayed compliance order, or court order.
- **Agreements** - Agreements are formed as a result of negotiations between a facility and the air control agency. It also is a way to get a source to come into compliance

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with the applicable regulations. Examples of some agreement types are consent decrees, stipulation agreements, and court settlements.

- **Permits** - A permit can be considered a discretionary program in that the issuing agency has a great deal of flexibility and authority for reaching its goals.

204.8 COMPLIANCE MONITORING STRATEGY (CMS)

The Clean Air Act Stationary Source Compliance Monitoring Strategy policy has been implemented by the EPA to increase the effectiveness of the air enforcement program. Effective October 1, 2001, EPA has requested that source test reporting methods be implemented. The policy emphasis has been placed on Title V major sources and a limited subset of synthetic minor sources.

A minimum number of reporting frequencies have been recommended for determining the compliance status of facilities covered by this policy. Alternatives may be developed and negotiated with the Regions to enable States/locals to address important local compliance issues.

The policy recognizes that a variety of tools ranging from self-certifications to traditional stack tests are available and should be used to evaluate compliance. It further recognizes that on-site visits may not be necessary to evaluate the compliance status of a facility given the wide range of self-reported information such as annual Title V compliance certifications, deviation reports, and semi-annual monitoring reports based on periodic monitoring and compliance assurance monitoring. However, to ensure a compliance presence in the field, a minimum frequency for on-site visits has been recommended.

204.8.1 Compliance Monitoring Categories

There are three categories of compliance monitoring: Full Compliance Evaluations, Partial Compliance Evaluations and Investigations. CMS plans may be submitted once every two years. The three categories are described as follows:

204.8.1.1 Full Compliance Evaluations

A Full Compliance Evaluation is a comprehensive evaluation of the compliance status of a facility. It addresses all regulated pollutants at all regulated emission units. Furthermore, it addresses the current compliance status of each emission unit, as well as

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the facility's continuing ability to maintain compliance at each emission unit. A Full Compliance Evaluation should include the following:

1. A review of all required reports, and to the extent necessary, the underlying records. This includes all monitored data reported to the regulatory agency (e.g., CEM and continuous parameter monitoring reports, malfunction reports, excess emission reports). It also includes a review of Title V self-certifications, semi-annual monitoring and periodic monitoring reports, and any other reports required by permit.
2. An assessment of control device and process operating conditions as appropriate. An on-site visit to make this assessment may not be necessary based upon factors such as the availability of continuous emission and periodic monitoring data, compliance certifications, and deviation reports. Examples of source categories that may not require an on-site visit to assess compliance include, but are not limited to, gas-fired compressor stations, boilers in large office and apartment buildings, peaking stations, and gas turbines.
3. A visible emission observation as needed.
4. A review of facility records and operating logs.
5. An assessment of process parameters such as feed rates, raw material compositions, and process rates.
6. An assessment of control equipment performance parameters (e.g., water flow rates, pressure drop, temperature, and electrostatic precipitator power levels).
7. A stack test where there is no other means for determining compliance with the emission limits. In determining whether a stack test is necessary, States/locals should consider factors such as: size of emission unit; time elapsed since last stack test; results of that test and margin of compliance; condition of control equipment; and availability and results of associated monitoring data.

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In addition to conducting a stack test when there is no other means of determining compliance, States/locals should conduct a stack test whenever they deem appropriate.

A Full Compliance Evaluation should be completed within the fiscal year in which the commitment is made, except in the case of extremely large, complex facilities (referred to as mega-sites). Regulatory agencies may take up to three years to complete a Full Compliance Evaluation at a mega-site, provided the agency is conducting frequent on-site visits or Partial Compliance Evaluations throughout the entire evaluation period.

A Full Compliance Evaluation may be done piecemeal through a series of Partial Compliance Evaluations.

204.8.1.2 Partial Compliance Evaluations

A Partial Compliance Evaluation is a documented compliance assessment focusing on a subset of regulated pollutants, regulatory requirements, or emission units at a given facility. A Partial Compliance Evaluation should be more comprehensive than a cursory review of individual reports. It may be conducted solely for the purpose of evaluating a specific aspect of a facility, or combined over the course of a year (or up to three years at mega-sites) to satisfy the requirements of a Full Compliance Evaluation.

This type of evaluation could be used for example to effectively assess compliance with the HON MACT requirements if that is the primary area of concern at a chemical manufacturing facility. If at some point later in the year, the regulatory agency decided a Full Compliance Evaluation was necessary, the agency could combine the results of the MACT evaluation with subsequent evaluations focusing on the balance of other CAA requirements.

204.8.1.3 Investigations

An Investigation can be distinguished from the other two categories in that generally it is limited to a portion of a facility, is more resource intensive, and involves a more in-depth assessment of a particular issue. It usually is based on information discovered during a Full Compliance Evaluation, or as the result of a targeted industry, regulatory or statutory initiative. Also, an Investigation often requires the use and analysis of information not available in EPA data systems. It is best used when addressing issues

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that are difficult to evaluate during a routine Full Compliance Evaluation because of time constraints, the type of preliminary field work required, or the level of analytical expertise needed to determine compliance.

204.8.2 Compliance Monitoring Strategy Goals

The CMS policy goals are as follows:

1. To provide national consistency in developing stationary source air compliance monitoring programs,
2. To improve communication between States/locals and Regions on stationary source air compliance monitoring programs, and enhance EPA oversight of these programs,
3. To provide a framework for developing stationary source air compliance monitoring programs that focuses on achieving measureable environmental results, and
4. To provide a mechanism for recognizing and utilizing the wide range of tools available for evaluating and determining compliance.

204.8.3 Compliance Monitoring Strategy Process

The overall CMS policy process is as follows:

1. States/locals submit a CMS plan biennially for discussion with and approval by the Regions. Regions also prepare a plan biennially for discussion with their States/locals.
2. The plans are summarized, and incorporated into the annual Regional response to the OECA Memorandum of Agreement (MOA).
3. States/locals and Regions maintain records of their compliance monitoring activities, and enter facility-specific compliance data in the national air data base (AIRS/AFS, or its successor).

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4. States/locals and Regions review the results of the compliance monitoring activities annually, and prepare an annual update to the biennial plan as necessary. Major redirections are discussed as they arise.
5. Regions conduct in-depth evaluations of the overall State/local compliance monitoring program periodically. Headquarters conducts similar evaluations of the Regional programs as well.

204.8.4 RECOMMENDED EVALUATION FREQUENCIES

The following minimum frequencies are recommended:

1. A Full Compliance Evaluation should be conducted, at a minimum, once every two years at all Title V major sources except those classified as mega-sites. For mega-sites, a Full Compliance Evaluation should be conducted, at a minimum, once every three years.
2. A Full Compliance Evaluation should be conducted, at a minimum, once every five years at synthetic minor sources that emit or have the potential to emit at or above 80 per cent of the Title V major source threshold.
3. An on-site visit should be conducted, at a minimum, once every five years at all Title V major sources to ensure a compliance presence in the field, verify record reviews, observe modifications or new construction, and identify any major permit deviations.

In those years when a Full Compliance Evaluation is not conducted, States/locals should continue to review annual compliance certifications, and the underlying reports supporting those certifications (e.g., semi-annual and periodic monitoring reports, continuous emission and continuous parametric monitoring reports, and malfunction and excess emission reports).

204.8.4.1 ALTERNATIVES TO THE RECOMMENDED EVALUATION FREQUENCIES

States/locals may develop with Regional approval alternatives to the recommended evaluation frequencies. Alternatives may be developed on a facility-by-facility basis, or for an entire source category. However, in determining whether an alternative frequency is appropriate, the following factors should be considered:

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- Compliance history
- Location of facility
- Potential environmental impact
- Operational practices (e.g., whether operation is steady state or seasonal),
- Use of control equipment,
- Participation in Agency-sponsored voluntary programs (e.g., Project XL, Performance Track),
- Identified deficiencies in the overall State/local compliance monitoring program.

204.8.5 COMPLIANCE MONITORING REPORTS

States/locals may continue to format compliance monitoring reports as they deem appropriate; however, the following basic elements should be addressed in the reports.

1. General information—date, compliance monitoring category (i.e., Full Compliance Evaluation, Partial Compliance Evaluation, or Investigation), and official submitting the report.
2. Facility information—facility name, location, mailing address, facility contact and phone number, Title V designation and mega-site designation.
3. Applicable Requirements—all applicable requirements including regulatory requirements and permit conditions.
4. Inventory and description of regulated emission units and processes.
5. Information on previous enforcement actions.
6. Compliance monitoring activities—processes and emission units evaluated; on-site observations; whether compliance assistance was provided and if so, nature of assistance; any action taken by facility to come back into compliance during on-site visit.
7. Findings and recommendations relayed to the facility during the compliance evaluation. Please note, this does not apply to information traditionally reserved for enforcement case files.

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8. Following are the codes that States/locals would use to report on stack tests:

JU	Source Test Conducted by the State
RU	Source Test Conducted by the District
JT	Source Test Witnessed by the State
RT	Source Test Witnessed by the District

In providing the above information, States/locals should reference or attach other relevant documents as appropriate to avoid duplication. For example, the relevant section of a Title V permit could be attached to the compliance monitoring report rather than rewriting all of the applicable requirements.

Compliance monitoring reports should be maintained and made available to the Regions upon request. Regions shall maintain similar files of regional activities and provide Headquarters with access upon request.

204.8.6 REPORTING

Changes will be made in the national air compliance data system (AIRS/AFS) to facilitate the reporting of information consistent with the revised structure of this policy. In addition, the Source Compliance and State Action Reporting ICR will be revised to incorporate the new data elements. In order to collect compliance information in a format that allows EPA to evaluate and compare compliance monitoring programs, Regions, and States/locals will need to:

- Continue to maintain records of compliance monitoring activities, and report these activities and the results in AIRS/AFS, or its successor, on a routine basis.
- Continue to designate the High Priority Violator (HPV) status of violating facilities in accordance with the EPA HPV Policy dated December 22, 1998.
- Utilize the following compliance monitoring categories to report activities at the facility level in AIRS/AFS, or its successor:
 - Full Compliance Evaluations
 - Partial Compliance Evaluations
 - Investigations

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Report the following information for all Title V annual compliance certification reviews in AIRS/AFS, or its successor:

- Date due
- Date received
- Whether deviations were reported
- Date reviewed
- Compliance status

Please note: Regions shall enter the first three data elements for each Title V compliance certification unless otherwise negotiated with States/locals.

- Enter the date and results of all stack tests in AIRS/AFS, or its successor, and adjust the HPV status as appropriate.

The compliance status of a facility will automatically revert from “in compliance” to “unknown” if a Full Compliance Evaluation is not completed:

- Within the recommended minimum frequencies, or
- In accordance with negotiated alternatives that extend the recommended minimum frequencies.

204.8.7 EVALUATION/OVERSIGHT

At the end of each fiscal year, the Regions shall evaluate whether the States/locals met their commitments, and in those cases where they did not, determine why they did not and what adjustments need to be made for the following year. EPA Headquarters shall in turn conduct a similar analysis nationally. This information should be transmitted back to the appropriate officials in a timely manner so that they can make mid-course corrections in their program if necessary.

Regions periodically shall conduct more in-depth analysis of the compliance monitoring program as a whole. They should look beyond how successful States/locals have been in meeting its commitments, and evaluate for example whether adequate inspector training is available; quality monitoring evaluations are being conducted; violations are being found and are significant enough to warrant enforcement action; and data are accurately reported in a timely manner. They should also assess whether States/locals

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are using an appropriate mix of compliance monitoring techniques, and making full use of all available data. In addition, Regions should attempt to quantify the impact of the compliance monitoring program on parameters such as compliance rates; specific and general deterrence; and moving beyond compliance. To the extent possible, Regions should inform States/locals in advance of the criteria that will be used in the more in-depth analyses.

Regions shall prepare and submit to Headquarters a plan describing the approach and schedule they intend to use for conducting these more in-depth evaluations.

Headquarters shall conduct similar evaluations of each Region, and use the information to monitor implementation of the policy; identify program deficiencies and successes; establish national trends; compare programs; and develop new national priorities. To the extent possible, Headquarters should inform Regions in advance of the criteria that will be used in evaluating Regional programs.

For a complete description of the AIRS reporting requirements, please review the website at www.epa.gov/ttn/airs.

Compliance Monitoring Strategy/AIRS reporting forms and matrices are contained in Appendix C of this manual.

204.9 IMPLICIT PROGRAMS

A regulatory agency may implement an implicit program through guidance documents. A guidance document may contain specific information about how monitors should be installed, certified, calibrated, or audited. Guidance documents may be incorporated into permits or agreements by reference.

205 REGULATIONS

Emission standards for stationary sources are established by both the U.S. EPA and by each state. The U.S. EPA promulgates engineering-based standards for "new" sources, whereas the states establish standards for "existing" sources so that ambient air quality standards can be met or attained. Existing sources are those constructed before the U.S. EPA adopted standards for a new source category.

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205.1 FEDERAL

"New Source Performance Standards" or NSPS, are found in Title 40, Protection of the Environment, Part 60 of the **Code of Federal Regulations (CFR)**. The CFR has established emission standards for specific source categories. Title 40 covers the U.S. EPA environmental regulations, and Part 60 includes the requirements for new stationary sources. Part 60 is divided into subparts, and each stationary source category is assigned a subpart. The subparts are listed in **Table 204.1**.

National Emission Standards for Hazardous Air Pollutants (NESHAPS) are contained in the following sections of the **Code of Federal Regulations**:

40CFR61
40CFR70
40CFR264
40CFR266

Hazardous air pollutant test methods are contained in EPA SW846, Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods.

205.2 STATE OF CALIFORNIA HEALTH & SAFETY CODE

The California Legislature passes laws, called statutes, that authorize Executive Branch Agencies such as the ARB to implement these statutes by adopting and enforcing regulations. The ARB directly regulates air pollution emissions from motor vehicles and some other sources. However, most industrial emission sources are regulated principally by the local APCD or AQMD. Following is a list of relevant California Health & Safety Code references which provide the basis for California Air Pollution Control Laws.

39000	Legislative Findings, Environment
39001	Legislative Findings - Agency Coordination
39002	Local and State Agency Responsibilities
39003	ARB Responsibilities
40000	Local/State Responsibilities
40001	Adoption and Enforcement of Rules and Regulations
42301	Requirements for Permit Issuance
42301.1	Issuance of Temporary Permit

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42301.6	Permit Approval: Powers and Duties of Air Pollution Control Officer
42301.7	Air Contaminants, Threatened Release
42303	Air Contaminant Discharge: Information Disclosure
42303.5	False Statements in Permit Applications
42304	Permit Suspension (Failure to Supply Information)
42352	Findings Required for Issuance of Variance
42400	General Violations, Criminal, \$15,000/Day and/or Nine Months Imprisonment (Maximum)
42400.1	Criminal Penalties, Negligence, \$100,000/Day and/or One Year Imprisonment (Maximum)
42400.2	Criminal Penalties, Knowingly, \$250,000/Day and/or One Year Imprisonment (Maximum)
42400.3	Criminal Penalties, Willfully, \$250,000/Day and/or One Year Imprisonment (Maximum) for Individuals, or \$1,000,000/Day and/or Three Years Imprisonment (Maximum) for Corporations.
42400.3.5	Criminal Penalties, Rule Violation, \$350,000/Day and/or Nine Months Imprisonment (Maximum)
42400.7	Recovery of Civil Penalties
42400.8	Determination of Fines
42401	Violating Order of Abatement, Civil
42402	General Violations, Civil
42402.1	Civil Penalties, Negligence, \$100,000/Day (Maximum)
42402.2	Civil Penalties, Knowingly, \$250,000/Day (Maximum)
42402.3	Civil Penalties, Willfully, \$1,000,000/Day (Maximum)
42402.4	Falsification of Records \$35,000/Day (Maximum)
42402.5	Civil Penalties, Administrative
42403	Civil Penalties, Relevant Circumstances
42402.4	Civil Penalties, Falsification of Documents
42404.5	Statute of Limitations for Civil Actions
42450	Orders of Abatement: District Board; Authority; Notice and Hearing
42700	Legislative Findings and Declarations (Monitoring Devices)
42701	Emissions Monitoring Devices
42702	Availability of Monitoring Devices
42703	Reimbursement for Actual Testing Expenses
42704	Determination of Availability, Revocation or Suspension
42705	Records
42706	Report of Violation of Emission Standard

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42707 Inspection; Fees
42708 Powers of Local or Regional Authority

205.3 LOCAL AIR DISTRICTS

In California, some APCDs and AQMDs have been delegated authority by the U.S. EPA to enforce the New Source Performance Standard (NSPS) and the National Emissions Standards for Hazardous Air Pollutants (NESHAPS). The EPA requires that all testing for these standards use its methods, unless alternate or equivalent status to its methods has been granted.

There are 35 air districts in California, all of which have individualized air pollution rules based upon the needs of the particular area. All districts, therefore, have adopted their own specific rules and regulations to enforce.

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To effectively perform a source test or observe a source test for compliance purposes, the tester must fully understand the fundamentals. These include gases and gas properties, temperature, volume, pressure, the gas laws, and isokinetic sampling. When performing a source test, a sample is extracted from a stack or duct into a source test apparatus. This process changes the sample in a number of ways, and consequently changes the character of the gas sample. It removes particulate matter from the gas, cools the gas down, and condenses out any water contained in the gas. The process also causes changes in the sample volume, gas temperature, and gas composition. All of these changes must be accounted for in source test calculations.

301 GAS PROPERTIES

Understanding the properties of gases is an important part of source testing. It will help the source test observer determine exactly how a sampling apparatus will affect a gas sample. Since source testing is a quantitative discipline, knowing how gases behave during the source test will assist in performing the correct calculations for the test.

301.1 GAS PRESSURE

Four measurements of pressure are important in source testing. These are barometric (atmospheric) pressure, gauge pressure, absolute pressure and partial pressure.

301.1.1 Barometric or Atmospheric Pressure

Barometric, or atmospheric pressure (P_b) is the pressure the atmosphere exerts on an object. It may be measured by a mercury column barometer. One atmosphere of pressure is defined as the force exerted by a 760 mm column of mercury on an area of 1 cm² at 15°C at sea level and at 45° north latitude. When an accurate barometer is not available for a source test, the local airport weather service is a good alternative. Local atmospheric pressure depends on elevation and weather conditions.

Changes in air density and regional and local air pressures are attributed to the heating and cooling of the atmosphere. Similarly, in stacks and ducts, pressures can also change, due to temperature changes in the stack.

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301.1.2 Gauge Pressure

Gauge pressure (P_g) is the pressure in a vessel or stack relative to atmospheric pressure. Gauge pressure will be a negative number if the vessel or stack is under a vacuum. A stack at atmospheric pressure will have a reading of 0 kPa (0 psig) gauge pressure.

301.1.3 Absolute Pressure

Absolute pressure (P_a) is the total pressure in a vessel or stack and is the sum of the gauge and atmospheric (barometric) pressures. Barometric pressure (P_b) is not likely to be exactly 14.7 psia. Most source testing calculations require pressures to be in absolute terms.

301.1.4 Partial Pressure

Partial pressure is the pressure exerted by one component of the gas. For example the partial pressures of nitrogen and oxygen in air are 80.1 kPa and 21.2 kPa respectively at a standard pressure of 101.3 kPa.

301.2 GAS TEMPERATURE

The effect of temperature on a volume of gas is important during a source test. If temperature increases, volume increases, and if temperature decreases, volume decreases. For each 1°C increase in temperature, the gas volume will increase by a factor of 1/273.16 (or 0.366%), or, upon cooling, the gas volume will decrease by a factor of 1/273.16. The limit to which an ideal gas can be cooled however, is negative 273.16°C, which defines absolute zero. The temperature cannot decrease by more than 273°C. For scientific and engineering calculations, and therefore source test calculations, temperature is frequently expressed on the absolute temperature scale in terms of degrees Kelvin (SI units) or degrees Rankine (English units). The Rankine scale is generally used in the United States for source sampling calculations. The conversion between the **Centigrade** scale and the **Kelvin** scale is:

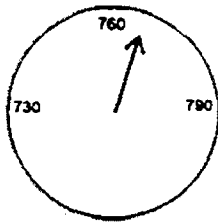
$$^{\circ}\text{K} = 273.16 + ^{\circ}\text{C}$$

The conversion between the **Fahrenheit** scale and the **Rankine** scale is:

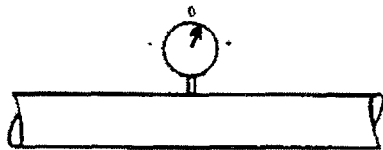
$$^{\circ}\text{R} = 459.67 + ^{\circ}\text{F}$$

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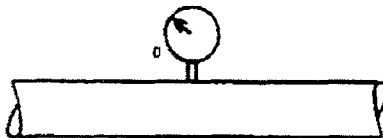
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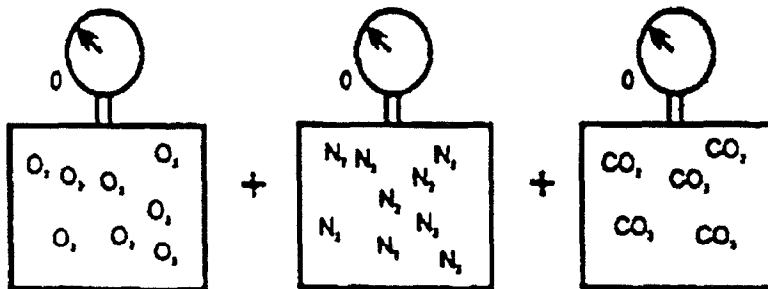
Pb - Atmospheric Pressure



Pg - Gauge Pressure



Pa - Absolute Pressure



Pp - Partial Pressure

Figure 302.3 Pressure Measurements

The conversion between the **Centigrade** and **Fahrenheit** scales are:

$$^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$$

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301.3 GAS VOLUME

In source testing, and in general, gas volume is dependent upon three variables. They are pressure, temperature, and the amount and composition of the gas. All of these variables will have a direct effect on a known volume of gas sample. The effect can be determined by using the **Ideal Gas Law**.

301.4 THE IDEAL GAS LAW

The **Ideal Gas Law** is an expression that relates absolute pressure (P_a), temperature (T), volume (V), and number of moles (n) of a gas. It applies to perfect, "ideal" gas molecules, that have mass and velocity, but no volume, do not repel or attract each other, and that do not release energy upon collision. The law works well at the conditions of pressure and temperature found in stack testing, and is typically used to correct from stack conditions of pressure and temperature to a set of standard conditions. The **Ideal Gas Law** equation below is derived from Boyle's Law, Charles' Law and Dalton's Law of Partial Pressures, and Avogadro's Hypothesis.

$$PV = nRT$$

Where:

- P = absolute pressure
- V = volume of a gas
- n = number of moles of a gas
- R = universal gas constant
- T = absolute temperature

301.4.1 Boyle's Law

Boyle's Law (1662) summarizes the gas property of compressibility. It states that when temperature is held constant, the volume of a perfect gas of a given composition varies inversely proportional to the absolute pressure exerted on it.

301.4.2 Charles' Law

Jacques Alexandre Cesar Charles (1746-1823) formulated the effect of temperature or thermal expansion on a volume of gas in 1787. It states that at constant pressure, the volume of a fixed weight of any gas is directly proportional to the absolute temperature.

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301.4.3 Dalton's Law of Partial Pressures

Dalton's Law (1801) states that in a mixture of gases, each gas exerts a pressure independent of the other gases present, and the total pressure is the sum of the partial pressure exerted by each gas in the mixture.

301.4.4 Avogadro's Hypothesis

Avogadro's Hypothesis (1811) states that equal volumes of gases at the same temperature and pressure contain the same number of molecules.

301.5 STACK GAS MOLECULAR WEIGHT

The stack gas molecular weight is calculated by measuring the amount of each gas component (volume percent), multiplied by the molecular weight of that component, and summing the component fractions. Molecular weight is the product of the mass per molecule times the number of molecules in a mole. The units of molecular weight are g/mol, kg/kmol, or lb/lbmol, however, units are sometimes omitted because weights are relative.

301.6 GAS DENSITY

Gas density is the mass of a gas in a specified volume. The mass is the product of the number of molecules of the gas and the molecular weight of each molecule. The density of the gas is related to its pressure and molecular weight. Temperature will also affect the pressure and therefore the gas density. A gas will have more molecules in the same volume at a higher pressure than at a lower pressure.

301.7 BERNOULLI'S PRINCIPLE

Bernoulli's principle states that the pressure in a fluid decreases with increased velocity of the fluid. This can be demonstrated with a simple garden hose and an attached flow valve. When the valve is closed, the water pressure increases. When the valve is open and the water is released, the velocity of the water increases, and pressure decreases. In a practical sense for source testing, Bernoulli's principle provides the basis for developing flow rate measuring devices such as the pitot tube and the orifice meter. The pitot tube equation for flue gas velocity in Method 2, Determination of

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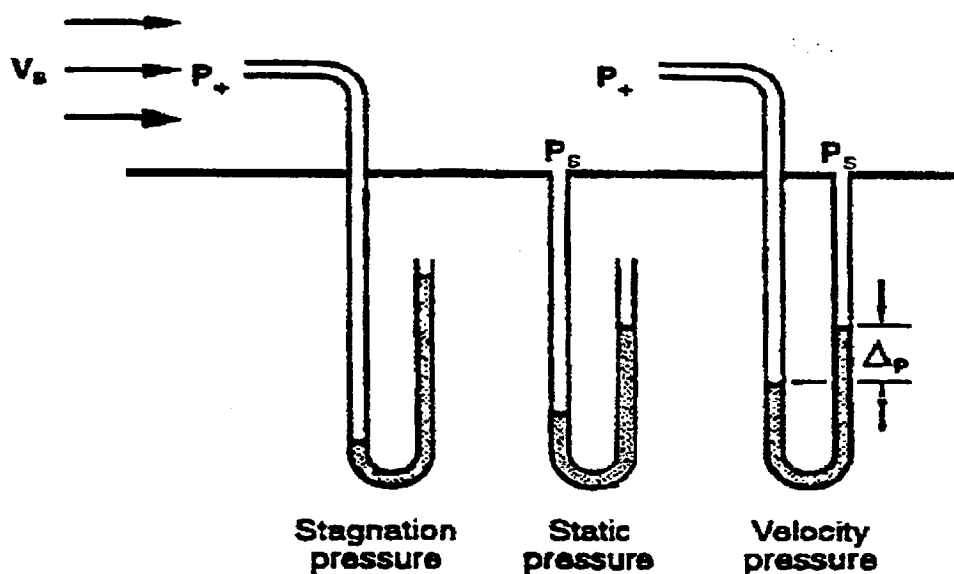


Figure 302.1 Total, Static, and Velocity Pressure Measurements

Stack Gas Velocity, and the orifice meter equation used in Method 5 are derived from this principle.

302 PRESSURE MEASUREMENT

When performing a source test, we must always consider the pressure of the atmosphere and its effect on the measurements we are obtaining. The ambient air exerts a pressure on us and our test apparatus. By measuring the atmospheric pressure with a barometer, we can enter the value into our source test calculations.

302.1 PITOT TUBE

The Type S pitot tube is the most common device used to measure the pressure of a moving gas stream to determine flow rate. The Type S fits easily into a stack port and it is rugged enough to withstand the corrosive and particulate laden stack environment. As shown in **Figure 302.1**, gas streams approaching the upstream pitot tube leg in a duct flow around the tube except at point "P". At point "P", the gas stream stagnates, and the total, or stagnation, pressure (p_t) is found. The down stream leg measures the static pressure (p_s) of the gas stream. The difference between the total pressure and

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the static pressure is the velocity pressure (Δp). Velocity pressure is used frequently in source test calculations using the following equation:

$$v_s = K_p C_p \sqrt{\frac{T_s \Delta p}{P_s M_s}}$$

Where:

v_s	= velocity of the stack gas
K_p	= dimensional constant
C_p	= pitot tube calibration coefficient
T_s	= absolute temperature of the gas
P_s	= absolute pressure of the stack gas
M_s	= molecular weight of the stack gas
Δp	= gas velocity pressure

302.2 ORIFICE METER

An orifice meter is a restriction-type flow meter which creates a pressure difference corresponding to the magnitude of the gas flow. The simplest type of orifice meter is a thin, flat plate held between flanges at a pipe joint with a circular hole in the middle. The plate is positioned perpendicular to the pipe axis with the hole concentric to the pipe. Pressure taps on each side of the plate measure the pressure difference caused by the restriction. The pressure differential is related to the rate of gas flow through the orifice using the equation:

$$Q_m = K_m \sqrt{\frac{T_m \Delta H}{P_m M_m}}$$

Where:

Q_m	= volumetric gas flow rate through orifice meter (m^3/sec , ft^3/sec)
ΔH	= pressure differential across orifice (mm H_2O , in. H_2O)
T_m	= absolute dry gas meter temperature ($^{\circ}K$ or $^{\circ}R$)
P_m	= absolute meter pressure (barometric mm Hg or in. Hg)
K_m	= orifice meter calibration factor (determined in lab)
M_m	= molecular weight of gas passing through meter (g/g-mole, lb/lb-mole)

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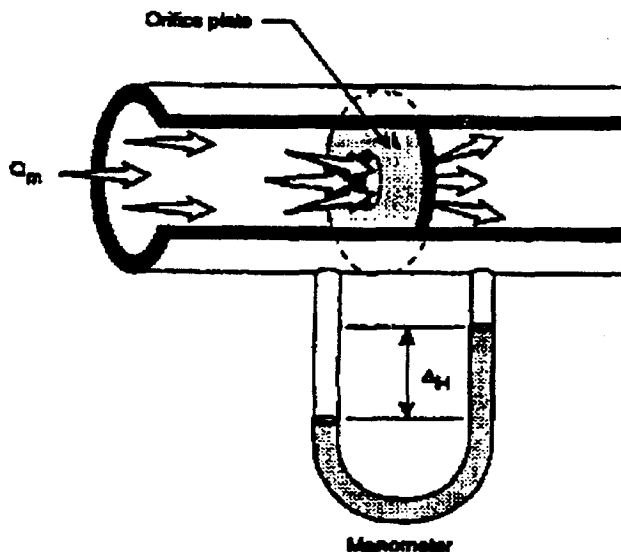


Figure 302.2 Simple Orifice Meter

302.3 BAROMETER

A barometer is used to measure barometric or atmospheric pressure. It is measured as inches or millimeters of mercury (Hg). A field barometer should be calibrated against a laboratory mercury barometer at a frequency specified by the test method. The field barometer should be adjusted to read within 5.1 mm (0.2 in.) Hg of the laboratory barometer, or it should be repaired or replaced. It should be well protected during travel.

303 ISOKINETIC SAMPLING

Isokinetic is defined as "in uniform or equal motion." Isokinetic sampling is an equal or uniform sampling of particles and gases in motion within the stack. Isokinetic source sampling is achieved when the velocity of gas entering the sampling nozzle is exactly equal to the velocity of the approaching gas stream. This provides a uniform, unbiased sample of the pollutants being emitted by the source. Sampling isokinetically is necessary in order to collect a representative sample of particulate matter, because of the way particles behave in a gas stream.

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The relationship between the velocity of the gas entering the sampling nozzle (v_n) and the velocity of the stack gas stream (v_s), is used in the following equation to determine the percent isokinetic of the sample. The percent isokinetic is defined as:

$$\% \text{ Isokinetic} = v_n / v_s \times 100$$

and is equal to 100% only when $v_n = v_s$. When v_n is not equal to v_s , anisokinetic conditions exist which means that the sample concentrations are biased due to the inertial effects of particles.

Particle sizes vary with different emission sources, but overall there will be a distribution of sizes in the flue gas stream. When the sample is taken isokinetically, the distribution of particle sizes entering the probe will be exactly the same as that in the flue gas itself. So, the particulate sample will be representative of the flue gas particle size distribution. **Figure 303.1** illustrates how different flow rates can affect a source sample.

In super-isokinetic conditions ($v_n > v_s$), the velocity of the nozzle inlet is greater than the velocity of the flue gas. The nozzle brings in gas from regions not directly in front of it. Therefore, the sample obtained will consist of too many small particles and not enough large particles, since smaller particles are lighter and pulled into the nozzle more quickly. The sample will be biased low.

In sub-isokinetic conditions ($v_n < v_s$), the flue gas velocity is greater than the nozzle inlet velocity, and therefore an excess of large particles, due to their inertia, will escape into the sample nozzle. The sample will be biased high.

As the gas stream moves through the plant ductwork or stack, particles will normally follow. However, when the gas stream makes a turn, or a disturbance exists, the particles may not be able to stay with the flow of gas. By sampling isokinetically, a sample is taken that does not distort the streamlines, and the sample will be representative of the flue gas particle size distribution. This technique also most closely evaluates and defines various parameters in the stack as they exist at the time of sampling.

It is important to maintain isokinetic conditions when sampling for particulate emissions. With gaseous sampling, sampling at isokinetic conditions is not a concern because gases follow the stream lines.

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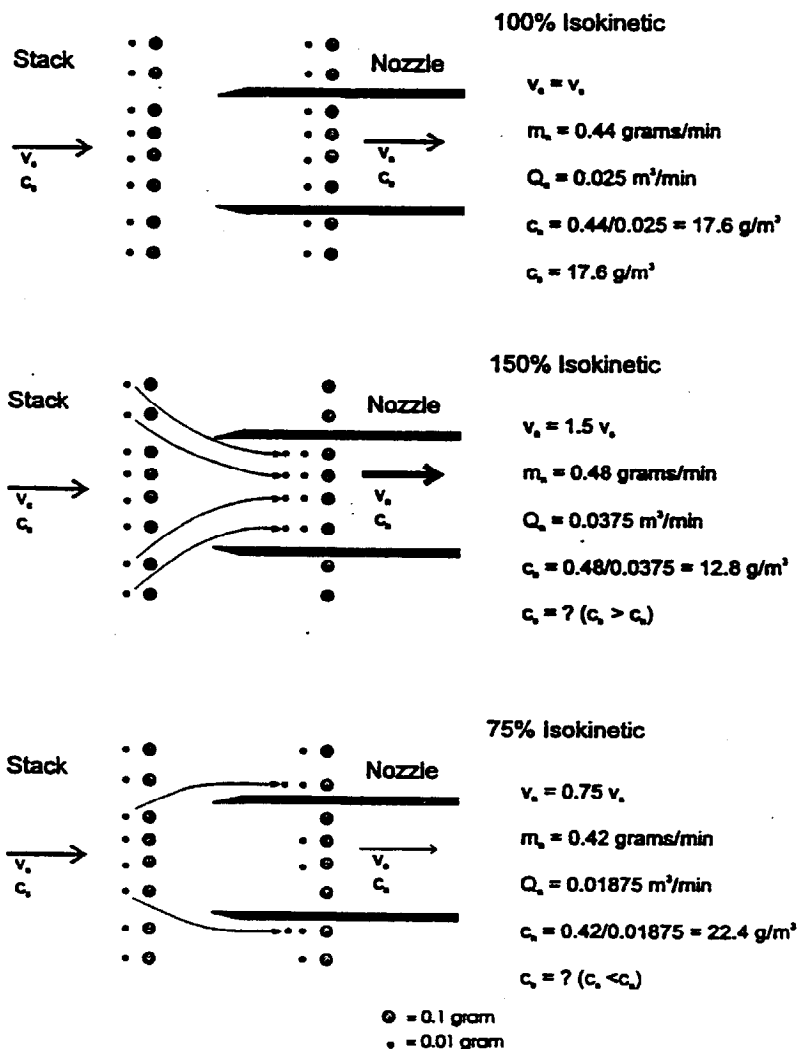


Figure 303.1 Isokinetic Sampling: Isokinetic, Superisokinetic, Subisokinetic

303.1 ISOKINETIC RATE EQUATION

Source testing teams use the **isokinetic rate equation** throughout the source test in order to maintain isokinetic conditions. The calculation of the equation is necessary in order to know how to adjust the sampling pump to obtain a flow rate through the nozzle that is equal to the stack gas velocity.

The isokinetic rate equation relates the measured value of the pressure drop, or Δp , across the pitot tube in the stack to the pressure drop, or ΔH , across an orifice meter in the sampling equipment, which we need to know if we are to sample isokinetically. The isokinetic rate equation is:

$$\Delta H = K_H D_n^4 \Delta H@ C_p^2 (1 - B_{ws})^2 \frac{M_d T_m P_s}{M_s T_s P_m} \Delta p$$

$$\text{or } \Delta H = K \Delta p$$

Where: K = an assemblage of constants and parameters that we obtain in our calibration procedures and source test pre-survey or otherwise assume.

In the equation, the expression $\Delta H@$ is defined as the orifice meter pressure differential that gives a flow rate of 0.75 cfm of airflow through the meter at 68° F and 29.92 in. Hg.

During the source test, the source tester observes the value of Δp at the sample point, solves the equation for ΔH and then sets the fine control knob on the Method 5 train meter box until the calculated value of ΔH is reached on the orifice meter manometer. This process is repeated at each traverse point or even during sampling at one traverse point, if the flue gas velocity is varying at that point. Source testers usually calculate the K factor before the test run. If all of the parameters remain constant during the test, then it becomes necessary to only multiply K by the new Δp reading at each traverse point.

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303.2 NOZZLE MISALIGNMENT

Even though the sampling may be performed isokinetically, the nozzle may be misaligned. As illustrated in **Figure 303.2**, the streamlines bend into the nozzle inlet, but the large particles are not able to make the turn. Consequently, the resultant particle concentration will be low. Always check the nozzle alignment prior to sampling.

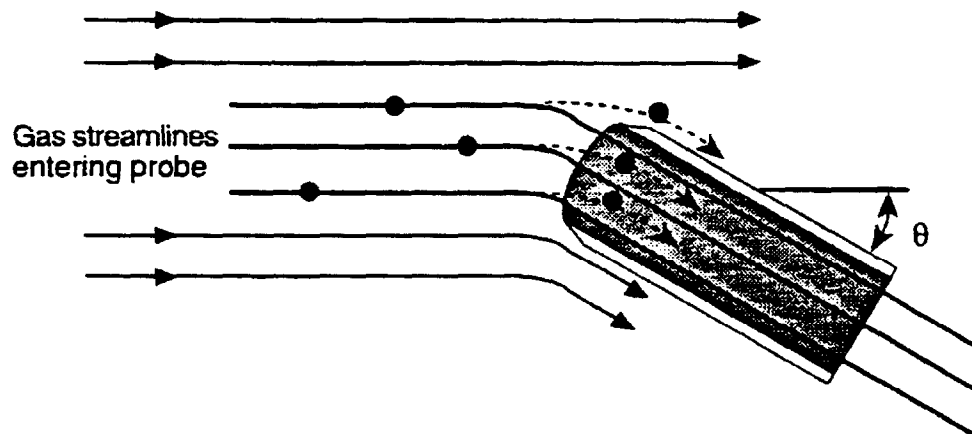


Figure 303.2 Nozzle Misalignment

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This section describes the most commonly used EPA and California Air Resources Board stack testing methods. ARB Methods 1 through 5, and ARB Method 100, Procedures for Continuous Emission Stack Sampling, are the basis for virtually all stationary source testing projects. They provide the procedures needed to determine the following:

- where and how to obtain a representative stack sample,
- how to quantify both sample and total stack gas velocities and volumes,
- how to determine stack gas moisture content and molecular weight so that pollutant emissions can be expressed in terms of both mass emitted for a given stack gas volume (concentration), and mass emitted per unit time (mass emission rate),
- how to determine carbon monoxide, nitrogen oxides, sulfur oxides, and total hydrocarbons emissions, and
- how to sample for particulate matter.

The Method 5 determination of particulate matter emissions is most important. It encompasses Methods 1 through 4, either directly or by reference, and is also the basis for most other stack testing methods, especially those for determining TAC emissions. Many TACs, such as chromium and dioxins, are sampled using "Modified Method 5" sampling trains and procedures. It is for this reason that Section 500 focuses on performing and observing a "Method 5" source test.

The ARB methods discussed are based on United States Environmental Protection Agency (U.S. EPA) reference methods. The ARB methods may have slight variations from the U.S. EPA reference methods, but have been approved for use by the U.S. EPA.

Section 94100 of the California Administrative Code requires ARB test methods to be used except when districts have adopted test methods, then 94100 requires source testing be conducted using their own test methods. These are, however, ARB and U.S. EPA approved methods. The local AQMD/APCD for the region where a source is to be tested should be consulted for their requirements. Remember that any compliance related source test must be coordinated with the AQMD/APCD.

The following ARB Stationary Source Test Methods are summarized in this section. Methods 1-5 and ARB Method 100 are discussed in detail, and other more common test methods are reviewed briefly. These methods as well as other source test methods are attached, in complete form, as Appendix B:

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- EPA/ARB Method 1 - Sample and Velocity Traverses for Stationary Sources
- EPA/ARB Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate
- EPA/ARB Method 3 - Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight
- EPA/ARB Method 4 - Determination of Moisture Content in Stack Gases
- EPA/ARB Method 5 - Determination of Particulate Matter Emissions from Stationary Sources.
- EPA/ARB Method 5A - Determination of Particulate Emissions from the Asphalt Processing and Asphalt Roofing Industry
- EPA Method 5B - Determination of Nonsulfuric Acid Particulate matter from Stationary Sources
- EPA/ARB Method 6 - Determination of Sulfur Dioxide Emissions from Stationary Sources
- EPA/ARB Method 7 - Determination of Nitrogen Oxide Emissions from Stationary Sources
- EPA/ARB Method 10 - Determination of Carbon Monoxide Emissions from Stationary Sources
- EPA/ARB Method 11 - Determination of Hydrogen Sulfide Content of Fuel Gas Streams in Petroleum Refineries
- EPA/ARB Method 17 - Determination of Particulate Matter Emissions from Stationary Sources (In-Stack Filtration Method)
- EPA Method 18 - Measurement of Gaseous Organic Compound Emissions by Gas Chromatography
- EPA/ARB Method 20 - Determination of Nitrogen Oxides, Sulfur Dioxide, and Diluent Emissions from Stationary Gas Turbines
- EPA/ARB Method 21 - Determination of Volatile Organic Compound Leaks
- ARB Method 100 - Procedures for Continuous Gaseous Emission Stack Sampling
- EPA Method 201 - PM10 Exhaust Gas Recycle Method (EGR)
- EPA Method 201A - Constant Sampling Rate Procedure (CSR)
- EPA Method 202 - Determination of Condensable Particulate Emissions from Stationary Sources

An expanded description for conducting and observing a source test project (a Method 5 source test), is presented in Section 500. Other source testing methods are referenced, and complete lists of all ARB and U.S. EPA Stationary Source Test Methods are provided in Appendix B. A series of helpful checklists for both source testers and test auditors/observers is contained in Appendix C.

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401 METHOD 1 -- SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

Method 1 specifies both the sampling site location and the number and location of the sampling points used with the Method 5 sampling probe during a source test. The closer a sampling point is to a disturbance, such as a bend or change in stack diameter, the greater chance that the flue gas velocity and/or the particulate matter concentration will not be uniform, and therefore require more sampling points.

401.1 PRINCIPLE AND APPLICABILITY

The principle of this test is to obtain a representative measurement of pollutant emissions and/or total volumetric flow rate from discrete sampling points. A measurement site where the effluent stream is flowing in a known direction is selected and the cross-section of the stack is divided into a number of equal areas. A traverse point is then located within each of these equal areas.

This method is applicable to flowing gas streams in ducts, stacks, and flues. The method cannot be used when: (1) flow is cyclonic or swirling; (2) a stack is smaller than about 0.30 meter (12 in.) in diameter or 0.071 m² (113 in.²) in cross-sectional area; or (3) the measurement site is less than two stack or duct diameters downstream or less than a half diameter upstream from a flow disturbance.

The requirements of this method must be considered before construction of a new facility from which emissions will be measured; failure to do so may require subsequent alterations to the stack or deviation from the standard procedure. Cases involving variants are subject to approval by the Control Agency's authorized representative.

401.2 SITE SELECTION AND NUMBER OF TRAVERSE POINTS

Sampling or velocity measurement is performed at a site ideally located at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame. If necessary, an alternative location may be selected, at a position at least two stack or duct diameters downstream and one-half diameter upstream from any flow disturbance. For a rectangular cross-section, an equivalent diameter (D_e) shall be

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calculated from the following equation, to determine the upstream and downstream distances.

$$D_e = \frac{2LW}{(L-W)}$$

Where L = length and W = width.

Once the sampling site is selected, the number of sampling points are determined. The EPA has established two sets of sampling point criteria: one for particulate traverses, the other for velocity traverses.

401.3 DETERMINING THE NUMBER OF TRAVERSE POINTS

The following section will aid in determining the number of traverse points to sample.

401.3.1 Particulate Traverses

When the eight-and-two-diameter criterion can be met, the minimum number of traverse points shall be: (1) twelve, for circular or rectangular stacks with diameters (or equivalent diameters) greater than 0.61 meter (24 in.); (2) eight, for circular stacks with diameters between 0.30 and 0.61 meter (12-24 in.); (3) nine, for rectangular stacks with equivalent diameters between 0.30 and 0.61 meter (12-24 in.).

When the eight- and two-diameter criterion cannot be met, the minimum number of traverse points is determined from **Figure 401.1**. (Note: The number of total traverse points is given; i.e., 12 points would be 6 per each diameter). Before referring to the figure, however, determine the distances from the chosen measurement site to the nearest upstream and downstream disturbances, and divide each distance by the stack diameter or equivalent diameter, to determine the distance in terms of the number of duct diameters. Then, determine from **Figure 401.1** the minimum number of traverse points that corresponds: (1) to the number of duct diameters upstream; and (2) to the number of diameters downstream. Select the higher of the two minimum numbers of traverse points, or a greater value, so that for circular stacks the number is a multiple of 4, and for rectangular stacks, the number is one of those shown in **Table 401.3**.

Details regarding determination of the number of traverse points for special test conditions are provided in the method (see Appendix B).

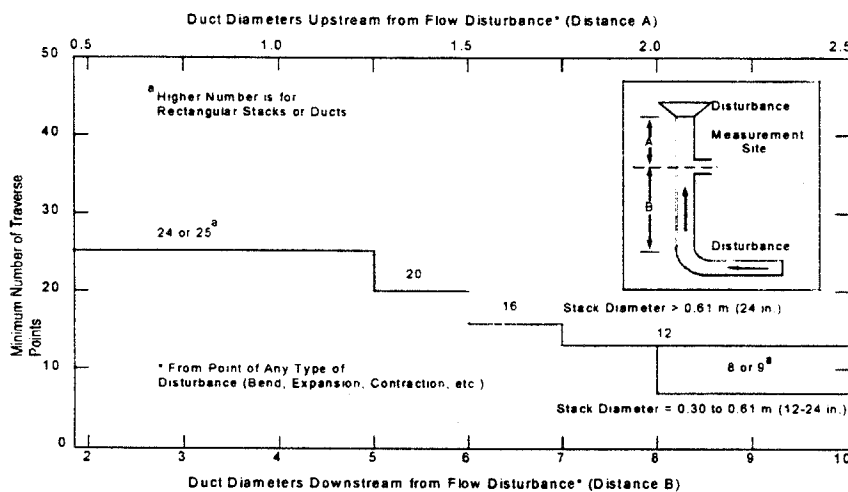


Figure 401.1 Minimum Number of Traverse Points for Particulate Traverses

401.3.2 Velocity (Non-Particulate) Traverses

When velocity or volumetric flow rate is to be determined (but not particulate matter), the same procedure as that for particulate traverses is followed, except that the diagram for nonparticulate traverses may be used instead of **Figure 401.1**. (Details regarding determination of the number of traverse points for nonparticulates required for rectangular ducts are provided in Appendix B).

401.4 LOCATION OF TRAVERSE POINTS FOR CIRCULAR STACKS

Locate the traverse points on two perpendicular diameters according to **Table 401.4**, and the example shown in **Figure 401.2**. For particulate traverses, one of the diameters must be in a plane containing the greatest expected concentration variation, e.g., after bends, one diameter shall be in the plane of the bend.

In addition, for stacks having diameters greater than 0.61 m (24 in.), no traverse points shall be located within 2.5 cm (1.00 in.) of the stack walls; and for stack diameters equal to or less than 0.61 m (24 in.) no traverse points shall be located within 1.3 cm (0.50 in.) of the stack walls. Traverse point selection for rectangular

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stacks, and for alternative conditions, are specified in the method to accommodate specific test situations.

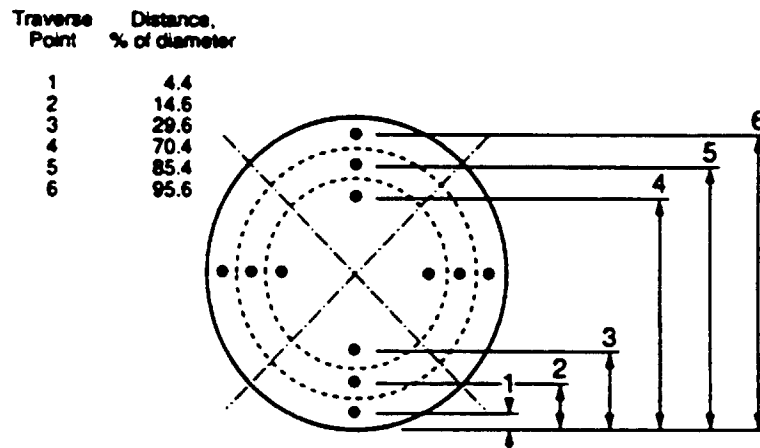


Figure 401.2 Circular Stack Cross-Section

401.5 LOCATION OF TRAVERSE POINTS FOR RECTANGULAR STACKS

Determine the number of traverse points as explained in the previous section of this method. From Table 401.3, determine the grid configuration. Divide the stack cross-section into as many equal rectangular elemental areas as traverse points, and then locate a traverse point at the centroid of each equal area according to the example in ARB Method I in Appendix B.

Table 401.3 Cross-Sectional Layout for Rectangular Stacks

Number of Traverse Points	Matrix Layout
9	3 x 3
12	4 x 3
16	4 x 4
20	5 x 4
25	5 x 5
30	6 x 5
36	6 x 6
42	7 x 6
49	7 x 7

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**Table 401.4 Location of Traverse Points in Circular Stacks
(Percent of stack diameter from inside wall to traverse point)**

Traverse Point Number on a Diameter	Number of Traverse Points on a Diameter											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.5	11.6	10.5
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.8	67.7
15								85.1	89.1	83.5	78.2	72.8
16								78.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9
19										96.1	91.3	86.8
20										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												99.9

401.6 CYCLONIC FLOW CHECK

In most stationary sources, the direction of stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations which tend to induce swirling; in these instances, the presence or absence of cyclonic flow at the sampling location must be determined.

To determine cyclonic flow, first zero and level the manometer and connect to a Type S pitot tube. Position the pitot tube at each traverse point so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane. This is termed the "0° reference" position. At each traverse point, note the differential pressure. If a zero pitot reading is obtained at 0° reference, then an acceptable flow condition exists at that point. If it is not zero, rotate the pitot tube (up to +/- 90° yaw angle), until a zero reading is obtained. Carefully determine and record the value of

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the rotation angle to the nearest degree. Calculate the average of the absolute values of all angles measured. If the average value is greater than 20° , the overall flow condition in the stack is unacceptable.

The complete procedure and required equipment for checking for cyclonic flow conditions is presented in the method. If the overall flow condition in the stack is unacceptable, an alternative methodology, subject to the approval of the Control Agency's authorized representative, must be used to perform accurate sample and velocity traverses.

For sources where measurement locations are less than 2 equivalent or duct diameters downstream or less than one-half duct diameter upstream from a flow disturbance, see the alternative in the method. The alternative should be limited to ducts larger than 24 in. in diameter where blockage and wall effects are minimal. A directional flow-sensing probe is used to measure pitch and yaw angles of the gas flow at 40 or more traverse points; the resultant angle is calculated and compared with acceptable criteria for mean and standard deviation.

402 METHOD 2 -- DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

Method 2 is used to determine flue gas velocity and volumetric flow rate using the Type S pitot tube. The method details focus mainly on the calibration of the probe itself. If the Type S probe meets certain design criteria, the source tester can then assume a value for its calibration coefficient, C_p .

The velocity pressure is measured by determining the difference between the stagnation pressure and the static pressure, and is measured by the pitot tube. The stagnation pressure is the pressure in an open tube placed into the direction of flow of the flue gas. Static or internal pressure is the pressure in the duct itself. The difference in pressure between the two taps, as measured on the manometer, is known as the pressure drop, or Δp .

The velocity pressure measurement is found by subtracting the internal stack pressure contribution (static pressure) from the total pressure at the tip of the tube. This velocity pressure can then be used in the pitot tube equation to calculate the flue gas velocity using:

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$$v_s = K_p C_p \sqrt{\frac{T_s \Delta p}{P_s M_s}}$$

Where:

v_s	= flue gas velocity (m/sec, ft/sec)
K_p	= dimensional constant
C_p	= pitot tube calibration coefficient
T_s	= absolute temperature of the gas
P_s	= absolute pressure of the stack gas
M_s	= molecular weight of the stack gas
Δp	= velocity head of the stack gas (pressure drop) (mm H ₂ or in. H ₂ O)

Method 2 is also used to certify flow monitors applied in continuous emission monitoring systems, found in 40 CFR 60 Appendix B and in 40 CFR 75 Appendix A.

402.1 PRINCIPLE AND APPLICABILITY

The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Staustscheibe or reverse type) pitot tube. This measurement is applicable for measurement of the average velocity of a gas stream and for quantifying gas flow. The procedure is not applicable at measurement sites which fail to meet the criteria of Method 1, Section 2.1. (Selection of measurement site). Also, the method shows how to determine cyclonic or swirling flow conditions.

402.2 EQUIPMENT

All specifications for equipment are listed below. A more detailed discussion is given in the actual test method contained in Appendix B.

402.2.1 Type S Pitot Tube

The Type S Pitot tube (Figure 402.1) shall be made of metal tubing (stainless steel.) The external tubing diameter should be between 0.48 and 0.95 cm (3/16 and 3/8 inch.) There shall be an equal distance from the base of each leg of the pitot tube to its face-opening plane; it is recommended that this distance be between 1.05 and 1.50 times the external tubing diameter. The face openings of the pitot tube should be aligned as shown in Figure 402.1.

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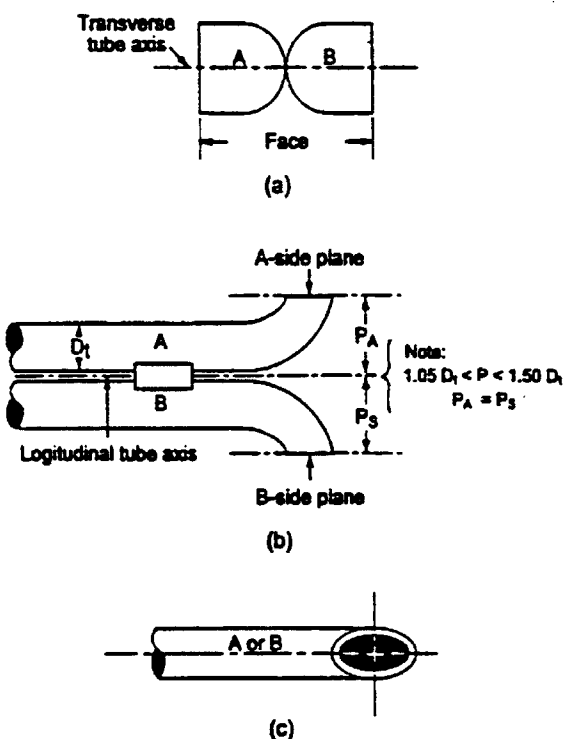


Figure 402.1 Properly Constructed Type S Pitot Tube

402.2.2 Differential Pressure Gauge

To measure differential pressure across the sampling train, an inclined manometer or equivalent device is used (shown in **Figure 402.2**). Most sampling trains are equipped with a 10-in. inclined-vertical manometer, which mark the 0.01-in. H_2O divisions on the inclined scale, and the 0.1-in. H_2O divisions on the vertical scale. This type of manometer is sufficient for the measurement of Δp values as low as 1.3mm (0.05 in.) in H_2O .

402.2.3 Temperature Gauge

A thermocouple, liquid-filled bulb thermometer, bimetallic thermometer, mercury-in-glass thermometer, or other gauge capable of measuring temperature to within 1.5 percent of the minimum absolute stack temperature shall be used. The temperature

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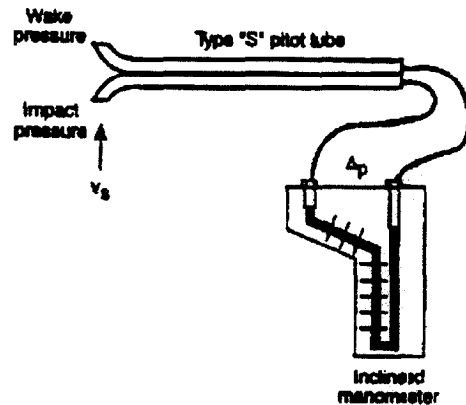


Figure 402.2 Type S pitot tube manometer assembly

gauge shall be attached to the pitot tube such that the sensor tip does not touch any metal, and without interference with respect to the pitot tube opening.

402.2.4 Pressure Probe and Gauge

A piezometer tube and oil or water-filled U-tube manometer capable of measuring stack pressure to within 2.5 mm (0.1 in.) is used.

402.2.5 Barometer

An aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.01 in. Hg) may be used. The barometric reading from a nearby national weather service station may also be used. However, an adjustment for elevation differences between the weather station and the sampling point shall be applied.

402.3 PROCEDURE

Assemble the apparatus as shown in **Figure 402.2**. **Conduct a pretest leak-check.** A post-test leak-check is also required. (Method 2, Section 3.3).

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402.3.1 Zeroing the Manometer

Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Record all necessary data as shown on the data sheet (see Appendix C, Data Reporting Forms).

402.3.2 Traverse Point Readings

Measure the velocity head and temperature at the traverse points specified by Method 1. Ensure that the proper differential pressure gauge is being used for the range of Δp values encountered. If it is necessary to change to a more sensitive gauge, do so, and re-measure the Δp and temperature readings at each traverse point. Conduct a post test leak-check (mandatory) to validate the traverse run.

402.3.3 Static Pressure Measurement

Measure the static pressure in the stack. One reading should be adequate.

402.3.4 Atmospheric Pressure

Determine the atmospheric pressure.

402.3.5 Stack Gas Dry Molecular Weight

Determine the stack gas dry molecular weight. For combustion processes or processes that emit essentially CO_2 , O_2 , CO and N_2 , use Method 3. For processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 29.0.

402.3.6 Moisture Content

Obtain the moisture content from Method 4 or from Method 5.

402.3.7 Stack Area

Determine the cross-sectional area of the stack or duct at the sampling location. Whenever possible, physically measure the stack dimensions rather than using blueprints.

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402.4 CALIBRATION

The value of the calibration factor (C_p) from a properly constructed Type S pitot tube will be approximately 0.84 (from 0.79 to 0.87).

402.4.1 Type S Pitot Tube

Before its initial use, carefully examine the Type S pitot tube in top, side and end views to verify that the face openings of the tube are aligned within the specifications illustrated in **Figure 402.1**. The pitot tube shall not be used if it fails to meet these alignment specifications. After verifying the face opening alignment, measure and record the dimensions of the pitot tube.

402.4.2 Type S Pitot Tube Assemblies

Many times the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle), as part of an assembly. During sample and velocity traverses, the presence of other sampling components can sometimes affect the baseline value of the Type S pitot tube coefficient. In these instances, an assigned baseline coefficient value may or may not be valid for a given assembly. The baseline and coefficient values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated.

402.4.3 Pitot Tube Calibration Setup

If the Type S pitot tube is to be calibrated, one leg of the tube shall be permanently marked A, and the other, B. Calibration shall be done in a flow system having the following essential design features:

The flowing gas stream must be confined to a duct of definite cross-sectional area, either circular or rectangular. For circular cross-sections, the minimum duct diameter shall be 30.5 cm; for rectangular cross-sections, the width shall be at least 25.4 cm. The cross-sectional area of the calibration duct must be constant over a distance of 10 or more duct diameters. For a rectangular cross-section, use an equivalent diameter, calculated from the following equation to determine the number of duct diameters:

$$D_e = 2LW/(L+W)$$

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Where, D_e = Equivalent diameter.
 L = Length.
 W = Width.

To ensure the presence of stable, fully developed flow patterns at the calibration site, the site must be located eight diameters downstream and two diameters upstream from the nearest disturbances.

The flow system should have the capacity to generate a test-section velocity of around 915 m/min (3,000 ft/min). This velocity must be constant with time to guarantee steady flow during calibration.

402.4.4 Calibration Procedure

Make sure that the manometer is properly filled and that the oil is free from contamination and is of the proper density. Inspect and leak-check all pitot lines; repair or replace if necessary. Level and zero the manometer. Turn on the fan and allow the flow to stabilize. Seal the Type S entry port. Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point, and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

Read Δp_s and enter its value in the data table. Remove the Type S pitot tube from the duct and disconnect it from the manometer. Repeat the above steps until three pairs of Δp readings have been obtained, then perform the calculations.

402.5 CALCULATIONS

For each of the Δp readings, calculate the value of the Type S pitot tube coefficient as follows:

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{\Delta P_{std}}{\Delta p_s}}$$

Where:

$C_{p(s)}$ = Type S pitot tube coefficient
 $C_{p(std)}$ = Standard pitot tube coefficient; use 0.99 if the coefficient is unknown.

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Δp_{std} = Velocity head is measured by the standard pitot tube, inches in H_2O

Δp_s = Velocity head measured by the Type S pitot tube, cm (in.) in H_2O .

Calculate C_p (side A), the mean A side coefficient, and C_p (side B), the mean B side coefficient; calculate the difference between these two average values.

Calculate the deviation of each of the three A-side values of $C_p(s)$ from C_p (side A), and the deviation of each B-side value of $C_p(s)$ from C_p (side B) using the following equation:

$$\text{Deviation} = C_{p(s)} - \bar{C}_p(A \text{ or } B)$$

Use the type S pitot tube only if the values from (side A) and (side B) are less than, or equal to, 0.01 and if the absolute value of the difference between C_p (A) and C_p (B) is 0.01 or less.

403 METHOD 3 -- GAS ANALYSIS FOR CARBON DIOXIDE, OXYGEN, EXCESS AIR, AND DRY MOLECULAR WEIGHT

Method 3 is used to determine the flue gas molecular weight, which is necessary for the solution of both the velocity equation and the isokinetic rate equation. The dry molecular weight for combustion processes is determined by the following equation:

$$M_d = 0.440 (\% CO_2) + 0.320 (\% O_2) + 0.280 (\% N_2 + \% CO)$$

This method is used to determine the percentage of CO_2 , O_2 and CO , (if carbon monoxide is present at measurable percentage levels). The percentage of nitrogen is found by subtracting the difference from 100. This method demonstrates the principle of partial pressures discussed in Section 301.1.4. For sources that contain percentage levels of other gases, the composition of the flue gas must be determined and the dry molecular weight adjusted to reflect the finding. A general equation is:

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levels of other gases, the composition of the flue gas must be determined and the dry molecular weight adjusted to reflect the finding. A general equation is:

$$M_d = \sum B_i M_i$$

Where: M_d = dry gas molecular weight
 B_i = mole fraction of gas i
 M_i = molecular weight of gas i

In using an Orsat analyzer, shown in **Figure 403.1**, a volume of the gas sample is drawn into the measuring burette. The burette holds water, which is alternately forced in and out of the leveling bottle. The gas sample is then alternately passed through attached tubes that hold different absorbing solutions. Potassium hydroxide is used to absorb carbon dioxide, alkaline pyrogallous acid to absorb oxygen, and a solution of cuprous chloride acid is used to absorb carbon monoxide. Although water is used in this procedure, and the sample gas becomes saturated, the measurement is a dry one because it is made by the differences in the burette. Any water vapor contribution cancels out.

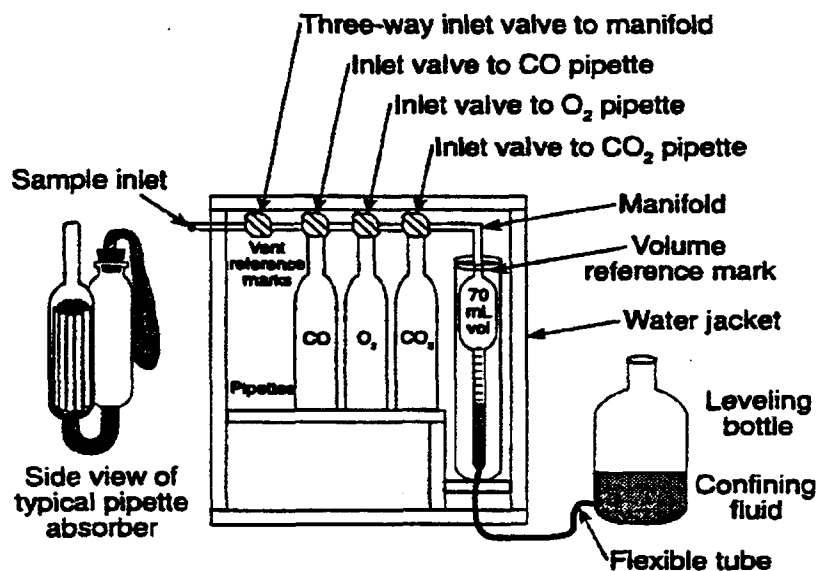


Figure 403.1 A typical Orsat Analyzer

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To obtain a sample for use in Method 3, either grab or integrated sampling techniques may be used. If the gas composition is unstratified and does not vary over time, then grab sampling is appropriate. Grab sampling utilizes a squeeze bulb which draws a sample through a glass wool filter, removes particulate matter, and passes it to the Orsat analyzer.

In integrated sampling, a sample is drawn into a Mylar bag over a period of time. If the flue gas composition is fluctuating over that period, the bag sample will represent an average of that composition.

During integrated sampling, the probe can be stationed at one point or moved to multiple points. If the percent oxygen or carbon dioxide is required for an F factor emissions calculation, a multi-point integrated sample is required. A discussion of F factors can be found in Section 403.6, Fuel Factor F_o , of this chapter.

Only those experienced in the use of an Orsat analyzer should be permitted to use it in a complicated source test. Currently, the use of automated analyzers has replaced the Orsat method. Method 3A allows the use of automated, instrumented techniques for flue gas component determinations.

403.1 PRINCIPLE AND APPLICABILITY

A gas sample is extracted from a stack by one of the following methods: (1) single-point, grab sampling; (2) single-point, integrated sampling; or (3) multi-point, integrated sampling. The gas sample is analyzed for percent CO_2 , percent O_2 , and, if necessary, percent CO. If a dry molecular weight determination is to be made, either an Orsat or a Fyrite analyzer or other analyzers specified in Method 100 may be used for the analysis; for excess air or emission rate correction factor determination, an Orsat analyzer or analyzers specified in Method 100 must be used.

To obtain a Method 3 sample, either grab or integrated sampling techniques may be used. Grab sampling is used when the gas composition is unstratified and does not vary over time. In integrated sampling, the sample is drawn into a Mylar bag over a period of time. The sample drawn will represent an average of the flue gas composition in cases where it fluctuates. Also, during integrated sampling, the probe can be stationed at one point or moved to multiple points. If the percent oxygen or carbon dioxide is required for an F factor emissions calculation, a multipoint integrated sample is required.

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Method 3 is applicable for determining CO₂ and O₂ concentrations; excess air, and dry molecular weight of the sample from a gas stream of a fossil-fuel combustion process. The method may also be applicable to other processes where it has been determined that compounds other than CO₂, O₂, CO, and N₂ are not present in concentrations sufficient to affect the results. Other methods, as well as modifications to the procedure described herein, are also applicable for some, or all, of the above determinations. Examples of specific methods and modifications include: (1) a multipoint sampling method using an Orsat analyzer to analyze individual grab samples obtained at each point; (2) a method using CO₂ or O₂ and stoichiometric calculations to determine dry molecular weight and excess air; (3) assigning a value of 30.0 for dry molecular weight in lieu of actual measurements, for processes burning natural gas, coal, or oil. These methods and modifications may be used, but are subject to the approval of the Control Agency's Authorized Representative.

403.2 EQUIPMENT

As an alternative to the sampling apparatus and systems described herein, other sampling systems (e.g., liquid displacement) may be used, provided such systems are capable of obtaining a representative sample and maintaining a constant sampling rate, and are otherwise capable of yielding acceptable results. Use of such systems is subject to the approval of the Control Agency's Authorized Representative.

403.2.1 Probe

The probe should be made of stainless steel or borosilicate glass tubing and should be equipped with an in-stack or out-stack filter to remove particulate matter (a plug of glass wool is satisfactory for this purpose). Any other material inert to O₂, CO₂, CO, and N₂ and resistant to temperature at sampling conditions may be used for the probe; examples of such material are aluminum, copper, quartz glass and Teflon.

403.2.2 Condenser

An air-cooled or water-cooled condenser, or other condenser that will not remove O₂, CO₂, CO, and N₂ may be used to remove excess moisture which would interfere with the operation of the pump and flow meter.

403.2.3 Pump/Valve

A needle valve is used to adjust gas sample flow rate. A leak-free, diaphragm-type pump, or equivalent, is used to transport the gas sample to the flexible bag. Install a

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small surge tank between the pump and rate meter to eliminate the pulsation effect of the diaphragm pump on the rotameter. Or, a one-way squeeze bulb, or equivalent, can be used to transport the gas sample to the analyzer.

403.2.4 Rate Meter

A rotameter, or equivalent rate meter, capable of measuring flow rate to within ± 2 percent of the selected flow rate should be used. A flow rate range of 500 to 1000 cc/min is suggested.

403.2.5 Flexible Bag

Any leak-free plastic (e.g., Tedlar, Mylar, Teflon) or plastic-coated aluminum (e.g., aluminized Mylar) bag, or equivalent, having a capacity consistent with the selected flow rate and time length of the test run, may be used. A capacity in the range of 55 to 90 liters is suggested.

To leak-check the bag, connect it to a water manometer and pressurize the bag to 5 to 10 cm H_2O (2 to 4 in H_2O), and allow to stand overnight. A deflated bag indicates a leak.

403.2.6 Pressure Gauge

A water-filled U-tube manometer, or equivalent, of about 30 cm (12 in) is used for the flexible bag leak-check.

403.2.7 Vacuum Gauge

A manometer of at least 760 mm Hg (30 in Hg) is used for the sampling train leak-check.

403.3 PROCEDURE

Assemble the equipment and follow the procedure outlined in ARB Method 3, Section 2.3, Analysis.

403.3.1 Leak Check

Just prior to sampling, leak-check the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of at least 250 mm Hg, plugging the outlet of the

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pump, and then turning off the pump. The vacuum should remain stable for at least half a minute. Evacuate the flexible bag. Connect the probe and place it in the stack, with the tip of the probe positioned at the sampling point; purging the sample line. Next, connect the bag and make sure that all the connections are tight.

After the sampling is completed, a leak-check of the system is required. For the results of the sampling to be valid, the system must pass the leak test before and after the sampling.

403.3.2 Sampling and Analysis

Sample at a constant rate. The sampling run should be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collection of at least 30 liters of sample gas is recommended; however, smaller volumes may be collected if desired. Obtain one integrated flue gas sample during each pollutant emission rate determination.

To ensure complete absorption of the CO₂, O₂, or CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes should be made between readings.

403.4 DRY MOLECULAR WEIGHT DETERMINATION

Any of three sampling and analytical procedures may be used for determining the dry molecular weight. They are:

- Single-Point, Grab Sampling and Analytical Procedure
- Single-point, Integrated Sampling and Analytical Procedure
- Multi-Point, Integrated Sampling and Analytical Procedure

403.5 EMISSION RATE CORRECTION FACTOR OR EXCESS AIR DETERMINATION

For emission rate correction factor determination, immediately analyze the sample for percent CO₂, or percent O₂. If excess air determination is desired, immediately analyze the sample for percent CO₂, O₂, and CO. Determine the percentage of the gas that is N₂ by subtracting the percent CO₂, percent O₂, and percent CO from 100 percent, and calculate the percent excess air using the following equation:

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$$\%EA = [\% O_2 - 0.5(\% CO)] / [0.264(\% N_2) - (\% O_2 - 0.5(\% CO))].$$

403.6 FUEL FACTOR F_o

Similar to the excess air concept, a fuel factor can be used in calculating emissions from combustion sources. During combustion of a fuel, a volume of stack gas is generated per heat content of the fuel. The emission rate (E) can be calculated by multiplying the emission concentration (c_e) by the F factor, corrected for a dilution factor (df), such as excess air. The value of the F factor will depend on the fuel type burned, the emission gas measured (O_2 or CO_2), and whether the value is based on wet or dry conditions. Another use of F factors is to check whether the ORSAT values determined by Method 3 are within an appropriate range.

Table 403.2 F Factors

Fuel Type	F_d		F_w		F_c		F_o
	dscm/J ($\times 10^{-7}$)	dscf/ 10 ⁶ BTU	wscm/J (10^{-7})	dscf/ 10 ⁶ BTU	scm/J (10^{-7})	scf/ 10 ⁶ BTU	
Coal: Anthracite	2.71	10,100	2.83	10,540	0.530	1,970	1.016-1.130
Bituminous	2.63	9,780	2.86	10,640	0.484	1,800	1.083-1.230
Lignite	2.65	9,860	3.21	10,950	0.513	1,910	1.016-1.130
Oil:	2.47 ¹	9,190 ¹	2.77 ¹	10,320 ¹	0.383 ¹	1,420 ¹	1.260-1.413 ²
							1.210-1.370 ³
Gas: Natural	2.43	8,710	2.85	10,610	0.287	1,040	1.600-1.836
Propane	2.34	8,710	2.74	10,200	0.321	1,190	1.434-1.586
Butane	2.34	8,710	2.79	10,390	0.337	1,250	1.405-1.553
Wood	2.48	9,240			0.492	1,830	1.000-1.120
Wood Bark	2.58	9,600			0.516	1,920	1.003-1.130
Municipal Waste	2.57	9,570			0.488	1,820	

¹ Crude, Residual, or Distillate, ² Distillate, ³ Residual

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When fuels are burned in combination, calculate the combined fuel F_d and F_c factors (as defined in EPA Method 19, 40 CFR 60 Appendix A) according to the procedure in EPA Method 19 Section 5.2.3. Then calculate the F factor as follows:

$$F_o = 0.209 F_d / F_c$$

Where:

F_o	= ratio of O_2 and CO_2 ORSAT values to tabulated values
F_d	= dry factor; includes all components except water
F_c	= carbon factor; includes only carbon dioxide

The F factor table, **Table 403.2**, is one of a number of tables published.

403.7 QUALITY CONTROL PROCEDURES

In most instances CO_2 or O_2 measurement is required, however, it is recommended that both CO_2 and O_2 be measured to provide a check on the quality of the data. The quality control procedure used validates the measured proportions of CO_2 and O_2 for the fuel type, but the method does not detect sample dilution resulting from leaks during or after sample collection.

404 METHOD 4 -- DETERMINATION OF MOISTURE CONTENT IN STACK GASES

For source sampling calculations, the determination of the moisture content is necessary. The isokinetic rate equations require that the dry and molecular weights, velocity, and moisture fraction be entered. The following is the expression for the wet molecular weight:

$$M_s = M_d (1 - B_{ws}) + 18B_{ws}$$

Where:

M_s	= wet molecular weight
M_d	= dry gas molecular weight
B_{ws}	= proportion of water vapor, by volume, in the gas stream

Moisture content of the flue gas can be estimated or measured by one of four methods:

- saturation pressure
- psychrometry

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- adsorption
- condensation

When a gas stream is saturated with water vapor, moisture content can be determined by a gas temperature measurement. For a given temperature, at saturation, the gas is holding the maximum amount of water vapor possible. A Water Vapor Calculations sheet contained in Appendix B, Method 4, of this manual, lists the moisture content for a given gas temperature.

If a gas stream is not saturated, a wet bulb-dry bulb technique is used to determine moisture content. The psychrometric technique involves obtaining the wet bulb and dry bulb temperatures of the flue gas and then using a psychrometric chart to determine the moisture content.

For low moisture concentrations, the adsorption method can be used. Water is adsorbed onto a solid that has a high affinity for water vapor. Weighing the tube after adsorption and comparing to the dry weight will give the amount collected.

Condensation is the final method used to determine moisture content. The flue gas is passed through impingers submerged into an ice bath, the water condenses and collects in the impingers. The volume of the water collected is then measured using a graduated cylinder. The moisture content is found by dividing the volume of water collected by the total volume of gas collected (wet + dry).

404.1 PRINCIPLE AND APPLICABILITY

A gas sample is extracted at a constant rate from the source; moisture is removed from the sample stream and determined either volumetrically or gravimetrically.

This method is applicable for determining the moisture content of stack gas. Two procedures are given. The first is a reference method, for accurate determinations of moisture content (such as are needed to calculate emission data). The second is an approximation method, which provides estimates of percent moisture to aid in setting isokinetic sampling rates prior to a pollutant emission measurement run. The approximation method described here is only a suggested approach; alternative means for approximating the moisture content, e.g., drying tubes, wet bulb-dry techniques, condensation techniques, stoichiometric calculations, and previous experience, etc., are also acceptable.

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The reference method is often conducted simultaneously with a pollutant emission measurement run; when it is, calculation of percent isokinetic, pollutant emission rate, etc., for the run shall be based upon the results of the reference method or its equivalent. These calculations shall not be based upon results of the approximation method, unless the approximation method is shown, to the satisfaction of the Executive Officer, to be capable of yielding results within 1 percent H_2O of the reference method.

404.2 EQUIPMENT/REAGENTS

This section reviews the equipment and reagents specific for the Method 4 test. All equipment used should be clean, in good repair, and calibrated if necessary.

404.2.1 Probe

The probe is constructed of stainless steel or glass tubing, sufficiently heated to prevent water condensation, and is equipped with a filter, either in-stack or heated out-stack to remove particulate matter.

When stack conditions permit, other metals or plastic tubing may be used for the probe, subject to the approval of the Control Agency's Authorized Representative.

404.2.2 Condenser

The condenser consists of four impingers connected in series with ground glass, leak-free fittings or any similarly leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with a 1.3 centimeter ID glass tube extending to about 1.3 cm from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications may be used, subject to the approval of the Control Agency's Authorized Representative.

The first two impinger will contain known volumes of water, the third shall be empty, and the fourth shall contain a known weight of number 6 to 16 mesh indicating type silica gel, or equivalent desiccant. Some ARB testers put silica gel in the cartridge, not in the impinger. A thermometer capable of measuring temperature to within $1^{\circ}C$, shall be placed at the outlet of the fourth impinger, for monitoring purposes.

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404.2.3 Metering System

Vacuum gauge, leak-free pump, thermometers capable of measuring temperatures to within 3°C, dry gas meter capable of measuring volume to within 2 percent, and related equipment. When the metering system is used in conjunction with a pitot tube, the system shall enable checks of isokinetic rates.

404.2.4 Barometer

Use a barometer capable of measuring atmospheric pressure to within 2.5mm Hg. In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between weather station and sampling point shall be applied at a rate of - 2.5 mm Hg per 30 m elevation increase or vice versa for elevation decrease.

404.2.5 Balance/Graduated Cylinder

To gravimetrically measure condensed water and moisture caught in the silica gel, balances shall be accurate to within 0.5g. Graduated cylinders for volumetric measurements shall have subdivisions no greater than 2 ml.

404.3 PROCEDURE

Follow the procedure for ARB Method 4 in Appendix B, Section 2.2, Procedure.

405 METHOD 5 -- DETERMINATION OF PARTICULATE MATTER EMISSIONS FROM STATIONARY SOURCES

ARB Method 5 is discussed in detail in the following Section: 500 Performing/ Observing the Source Test. The EPA Method 5 includes only particulate collected on the filter and recovered from the front of the filter holder, probe, and connecting glassware in front of the filter in particulate concentration calculations, known as the "front-half" of the sampling train. Whereas, the ARB method also includes the condensible particulate from the "back-half" of the sampling train which includes the impingers and the particulate recovered from the glassware in the back of the filter.

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405.1 PRINCIPLE AND APPLICABILITY

This method is applicable for the determination of particulate emissions from stationary sources.

Particulate matter is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at a temperature in the range of 120°C plus or minus 14°C (248°F plus or minus 25°F) or such other temperatures as specified by an applicable subpart of the standards or approved by the Control Agency's Authorized Representative for a particulate applications. The particulate mass is determined gravimetrically after removal of uncombined water. ARB Method 5 includes the material condensing in the impingers. Since the definition of particulate matter is not consistent in all rules, the particulate matter catch should be itemized by weight as follows: (1) Filter catch, (2) Probe catch, (3) Impinger Catch, and (4) Solvent Extract to allow adjustment of the particulate matter determination to be consistent with the applicable regulation.

405.2 METHOD 5 SAMPLING TRAIN

A schematic of the sampling train used in this method is shown in **Figure 405.1**. The Method 5 sampling apparatus has been designed to perform isokinetic sampling. The apparatus, called the sampling train, combines several components, each having a different function.

An expanded description for conducting and observing a source test project (a Method 5 source test), along with helpful checklists for both source testers and test auditors/observers, is presented in Section 500. Other source testing methods are referenced, and complete ARB and U.S. EPA Stationary Source Test Methods are provided in Appendix B.

406 ARB METHOD 100 -- PROCEDURES FOR CONTINUOUS GASEOUS EMISSION STACK SAMPLING

406.1 PRINCIPLE AND APPLICABILITY

A sample of an exhaust gas stream is extracted, conditioned, and analyzed continuously by instruments. The measurements made by the continuous analyzers are used to determine average emission concentrations. By measuring the stack gas flow

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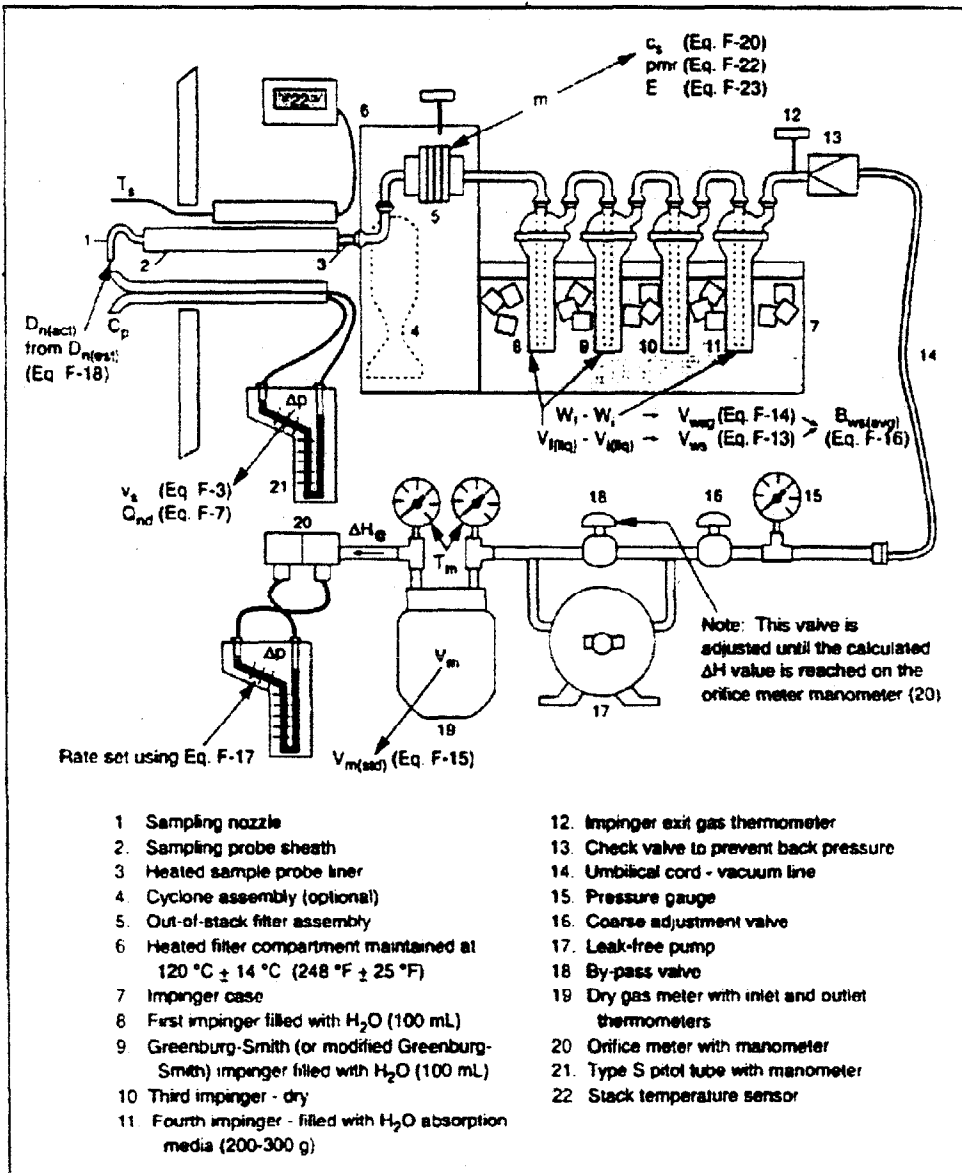


Figure 405.1 Method 5 Sampling Train

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rate and using this information with the average emission concentration, mass emission rates can be determined.

This method is applicable for determining emissions of oxides of nitrogen, carbon monoxide, carbon dioxide, sulfur dioxide, total hydrocarbons, and oxygen from stationary source flowing gas streams in ducts, stacks and flues. This procedure does not supercede the New Source Performance Standards (NSPS) requirement for permanently installed continuous monitoring instruments.

This test procedure is an alternative method to appropriate U.S. EPA reference methods, in particular, EPA methods 3, 6, 7 and 10. This procedure should be used only on those sources where equivalency to the reference methods has been established or the specific regulations for the source specify this procedure. Other continuous gaseous sampling methods that employ the principle stated in the section above but differ in details of equipment and operation may be used, provided that the method criteria are met.

406.1.1 METHOD 100 SAMPLING TRAIN

The sampling train for Method 100 is shown in **Figure 406.1**.

406.2 EQUIPMENT

The equipment listed is specific for the Method 100 test.

406.2.1 Nozzle/Filter/Probe/Heated Sample Line

The nozzle should be constructed of quartz, borosilicate glass, stainless steel, porcelain or aluminum oxide. An internal or external probe filter may be used. Provisions should be made for back flushing the filter to remove particulate buildup, as required. The probe shall have an inside diameter of 6 mm or larger and shall be constructed of quartz, borosilicate glass, stainless steel, aluminum oxide or porcelain. The sample line should be made from teflon or other material which does not absorb or otherwise alter the sample gas.

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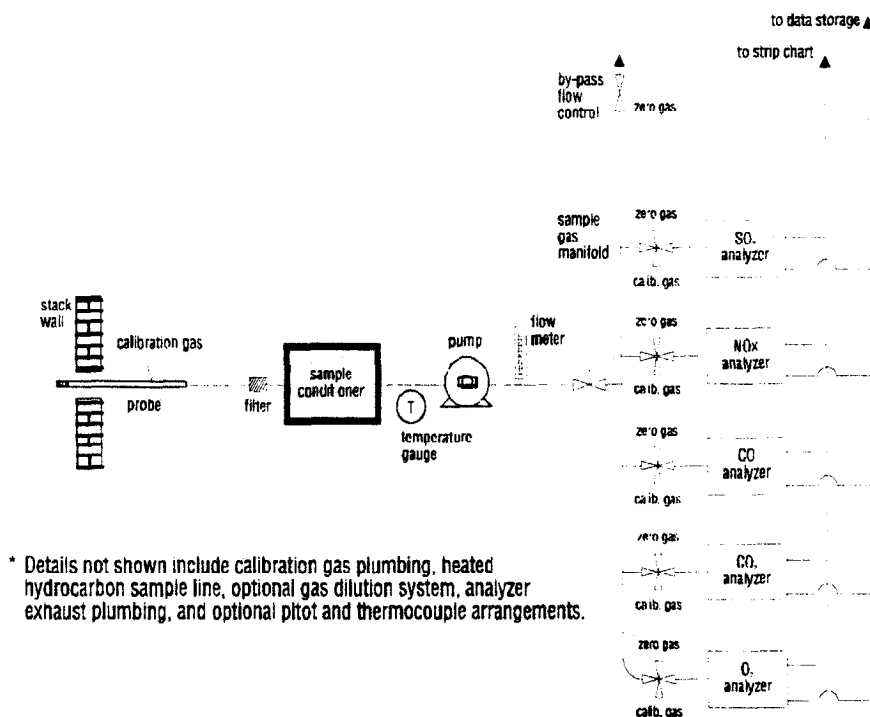


Figure 406.1 Method 100 Sampling Train

406.2.2 Probe Calibration System

Calibration gases are used for continuous analyzer calibration error checks and are introduced at the probe. Calibration gases can be introduced at the internal probe filter, at the probe tip, or directly behind the probe outlet, depending on the configuration of the probe. Alternately introduce zero and calibration gases to the instruments and make all necessary adjustments to calibrate the analyzer and the data recorder.

406.2.3 Sample Conditioner

The sample conditioner shall be capable of lowering the gas temperature to 15°C, or to 11°C lower than the ambient temperature, whichever is lower. All areas of the conditioner that are exposed to the sample shall be glass, stainless steel or teflon. A temperature gauge must be used to determine the temperature of the condenser outlet.

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406.2.4 Gas Analyzers

Specifications - The gas analyzer vendor must provide test data demonstrating that the following performance requirements are met: minimum detection limit, noise level, response time, repeatability, linearity, interference, sensitivity to temperature change, and 24 hour zero and calibration drift limits. The analyzers shall be housed in a temperature-controlled, vibration free environment.

Carbon Dioxide and Carbon Monoxide - Nondispersive infrared analyzers are acceptable.

Oxygen - An electrochemical (fuel cell) or paramagnetic analyzer is acceptable.

Total Hydrocarbons - An analyzer that utilizes a flame ionization detector (FID) or a nondispersive infrared analyzer (NDIR) is acceptable for use. Methane or propane is commonly used as a span gas. In order to assure that the detector will respond predictably to the organic compound present, the hydrocarbon species should be characterized prior to the source test.

Oxides of Nitrogen - A NO_2 to NO conversion efficiency test should be performed. Mid-level NO to N_2 calibration gas cylinder gas is added to a clean, evacuated, leak-tight Tedlar bag. Dilute the gas to 1:1 with 20.9 percent O_2 , purified air. Quickly attach the bag outlet to the calibration valve assembly and begin operation of the sampling system. Record the NO_x response, for at least 30 minutes. If the NO_2 to NO conversion is 100 percent, the instrument response will be stable at the highest peak value observed. If the response at the end of 30 minutes decreases more than 2 percent of the highest peak value, the system is not acceptable and corrections must be made before repeating the check.

Sulfur Dioxide - Use of an analyzer that uses infrared or ultraviolet absorption or fluorescence is acceptable.

Other Analyzers - The performance of the analyzer used must meet the requirements of Table 100.1 (see Appendix B, ARB Method 100)

Data Acquisition/Recorder System - A strip chart recorder, data logger, or other electronic data acquisition system should be used to provide a permanent record of gas analyzer data. The data acquisition system used must be capable of integration at

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a ten second interval. Also, the strip chart and data acquisition system used must have a resolution of 0.5 percent of the analyzer range. Pertinent data includes: pollutant, source, analyzer range, date, time, zero offsets, person operating instruments, and any other data that is important to the test.

406.2.5 Stack Gas Flowrate and Moisture Measurement Equipment

Stack gas flowrate and gas moisture content can be determined using specified equipment outlined in ARB test Methods 1 through 4. The stack gas velocity can be determined from the pitot tube measurement specified by Methods 1 and 2.

Alternatives that may be used are:

1. A simultaneous traverse of stack gas concentration and velocity, and
2. A pre and post test velocity traverse.

If the pitot tube and the sampling probe are used in combination in a testing assembly, care must be taken that any aerodynamic effects on the pitot tube are eliminated. If not, then the pitot tube must be calibrated with the other components of the test assembly in place.

406.2.6 Calibration Gases

All calibration gases must be certified according to EPA Traceability Protocol. (Refer to "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards" EPA-600/R23/224, Revised September 1993.) Otherwise, the calibration gases must be certified to an analytical accuracy of plus or minus 2 percent, traceable to a reference material approved by the National Institute of Standards and Technology (NIST), and recertified annually. Multicomponent gas mixtures certified according to EPA Protocol are acceptable.

For each pollutant to be measured, use the following three calibration gases:

High-Range Gas - The concentration should be between 80 and 100 percent of the analyzer range.

Mid-Range Gas - The concentration should be between 40 and 60 percent of the analyzer range.

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Zero-Range Gas - Purified air or nitrogen with a contaminant concentration less than 0.25 percent of the analyzer range for the appropriate pollutant gas.

The range should include the maximum expected ppmv concentration for the gas expected, and the actual measured concentration should be no less than 20 percent of the range for sufficient resolution.

406.2.7 Gas Dilution System

An approved gas dilution system may be used to provide low-level calibration gases from a high-level calibration gas. Calibration gas used with a gas dilution system must be an EPA Protocol gas, or be certified to an analytical accuracy of plus or minus one percent, NIST-traceable, and recertified annually. Also an approved gas dilution system may be used for all analyzer calibrations and sampling system bias checks.

406.3 PROCEDURE

The procedure is outlined in ARB Method 100, Section 4, Preparation for Sampling, and Section 5, Sampling.

406.3.1 Clean/Assemble Sample Train

The sample train may be cleaned prior to being transported to the field. When at the testing site, assemble the cleaned sample train as in **Figure 406.1**.

406.3.2 Calibrate Continuous Analyzers

Warm up the analyzers according to manufacturers instructions. Adjust the system components to achieve the individual analyzer sampling rates recommended by the manufacturer. Introduce zero and calibration gases alternately to the instruments and make all necessary adjustments to calibrate the analyzer and the data recorder.

Perform the analyzer calibration error check by introducing the three calibration gases (high-range, mid-range, and zero gas) in sequence, and recording the analyzer response to each calibration gas. Adjust system only to achieve the proper calibration gas flow rate. The analyzer calibration error for any calibration gas should not exceed +2 percent of the range.

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406.3.3 Leak Check

Perform a leak check on the vacuum side of the assembly at the maximum pump vacuum. Fix any leaks found, repeat the leak check and correction procedure until no leak is found.

406.3.4 Sample System Bias Check

For each gas analyzer, a pretest sampling system bias check is required. The sampling system bias check is performed by alternately introducing the zero gas and either the high-range or mid-range calibration gas at the probe, or whichever calibration gas is closest in concentration to the sample gas. Record the gas concentrations displayed. Determine the sampling system response time.

The difference between the measured gas concentrations for the analyzer calibration error check and the sample system bias check should not exceed 5 percent of the range for either the zero or higher calibration gas. If the difference exceeds that amount, corrective action needs to be taken. If the analyzer needs to be adjusted, then repeat the analyzer calibration error check before repeating the bias check.

406.3.5 Sample Collection

To collect the sample, first insert the sample probe into the stack and block off the remainder of the sample port opening. Place the probe at the predetermined position and begin to collect data. When changing traverse points, the sampling time at each point should remain constant, and for at least the response time plus one minute.

A complete test shall include at least three sampling runs. Each sample run shall be for the length of time specified in the applicable emissions limit regulation. If a sample run is conducted for more than two hours, a sample bias check should be completed every two hours. Performance check data should be recorded. To prevent particulate buildup on the probe filter, back flush through the probe periodically. Also check the sample conditioner and remove condensate of the test run.

406.3.6 Post Test Performance Checks

At the completion of the sample run, conduct a bias check for all analyzers. During the sampling system check operate the system at the normal sampling rate and do not

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make any adjustments to the system other than those necessary to achieve proper calibration gas flow rates.

406.4 CALCULATIONS

406.4.1 Zero and Calibration Drift

The difference between the zero or calibration gas measured for the post run sampling system bias check and the initial test run sampling system bias check should not exceed +/- 3 percent of the range, or the test shall be considered invalid. Use the following equation to determine the drift:

$$\text{Drift} = \frac{(c_{ib} - c_{fb})}{r} \times 100$$

Where:

- c_{fb} = analyzer response for the zero or upscale calibration gas for post run sampling system bias check.
- c_{ib} = analyzer response for the zero or upscale calibration gas for initial sampling system bias check.
- r = analyzer range

406.4.2 Other Calculations

Please refer to Appendix B, ARB test Method 100 for calculation procedures and equations to determine the sampling system bias, pollutant concentration and mass emission rate, and pollutant concentration for 12 percent CO₂ or 3 percent O₂.

407 OTHER SOURCE TEST METHODS

The U.S. EPA and the California Air Resources Board have developed many other tests methods for stationary source emissions testing. In addition to the methods discussed above, EPA has promulgated over 90 more test methods. ARB has 21 stationary source test methods authorized for use in California. Most methods cover pollutant gases, and are applied to specific source categories. New test methods and method amendments are continually being developed, evaluated, and cross-checked with other methods and data to validate their use. Some of the more basic methods are listed below, with a brief description of their principles and applicabilities.

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407.1 METHOD 5A - DETERMINATION OF PARTICULATE EMISSIONS FROM THE ASPHALT PROCESSING AND ASPHALT ROOFING INDUSTRY

407.1.1 Principle and Applicability

Particulate matter is withdrawn isokinetically from the source and collected on a glass filter fiber maintained at a temperature of $42^{\circ} \pm 10^{\circ}\text{C}$ ($108^{\circ} \pm 18^{\circ}\text{F}$). The particulate mass, which includes any material that condenses at or above the filtration temperature, is determined gravimetrically after removal of uncombined water.

This method applies to the determination of particulate emissions from asphalt roofing industry process saturators, blowing stills, and other sources as specified in the regulation.

407.2 METHOD 5B - DETERMINATION OF NONSULFURIC ACID PARTICULATE MATTER EMISSIONS FROM STATIONARY SOURCES.

407.2.1 Principle and Applicability

This method is applicable for the determination of nonsulfuric acid particulate matter from stationary sources, only where specified by an applicable subpart of the regulations, or where approved by the Administrator for a particular application.

407.3 METHOD 6 - DETERMINATION OF SULFUR DIOXIDE EMISSIONS FROM STATIONARY SOURCES

407.3.1 Principle and Applicability

A gas sample is extracted from the sampling point in the stack. The sulfuric acid mist (including sulfur trioxide) and the sulfur dioxide are separated. The sulfur dioxide fraction is measured by the barium-thorin titration method.

This method is applicable for the determination of sulfur dioxide emissions from stationary sources. The minimum detectable limit of the method has been determined to be 3.4 milligrams (mg) of SO_2/m^3 ($2.12 \times 10^{-7} \text{ lb/ft}^3$). Although no upper limit has been established, tests have shown that concentrations as high as 80,000 mg/ m^3 of SO_2 can be collected efficiently in two midjet impingers, each containing 15 milliliters

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of 3 percent hydrogen peroxide, at a rate of 1.01 pm for 20 minutes. Based on theoretical calculations, the upper concentration limit in a 20-liter sample is about 93,300 mg/m³.

Possible interferants are free ammonia, water-soluble cations, and fluorides. The cations and fluorides are removed by glass wool filters and an isopropanol bubbler, and hence do not affect the SO₂ analysis. When samples are being taken from a gas stream with high concentrations of very fine metallic fumes (such as in inlets to control devices), a high-efficiency, glass-fiber filter must be used in place of the glass wool plug (i.e., the one in the probe), to remove the cation interferant.

Free ammonia interferes by reacting with SO₂ to form particulate sulfite and by reacting with the indicator. If free ammonia is present, alternative methods subject to the approval of the Control Agency's Authorized Representative, are required.

407.4 METHOD 7 - DETERMINATION OF NITROGEN OXIDE EMISSIONS FROM STATIONARY SOURCES

407.4.1 Principle and Applicability

A grab sample is collected in an evacuated flask containing a dilute sulfuric acid-hydrogen peroxide absorbing solution, and the nitrogen oxides, except nitrous oxide, are measured colorimetrically using the phenoldisulfonic acid (PDS) procedure.

This method is applicable to the measurement of nitrogen oxides emitted from stationary sources. The range of the method has been determined to be 2 to 400 milligrams NO_x (as NO₂) per dry standard cubic meter, without having to dilute the sample.

407.5 METHOD 10 - DETERMINATION OF CARBON MONOXIDE EMISSIONS FROM STATIONARY SOURCES

407.5.1 Principle and Applicability

An integrated or continuous gas sample is extracted from a sampling point and analyzed for carbon monoxide (CO) content using a nondispersive infrared (NDIR) analyzer or equivalent.

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This method is applicable for the determination of carbon monoxide emissions from stationary sources only when specified by the test procedures for determining compliance with new source performance standards. The test procedure will indicate whether a continuous or an integrated sample is to be used.

407.6 METHOD 11 - DETERMINATION OF HYDROGEN SULFIDE CONTENT OF FUEL GAS STREAMS IN PETROLEUM REFINERIES

407.6.1 Principle and Applicability

Hydrogen sulfide (H_2S) is collected from a source in a series of midjet impingers and absorbed in pH 3.0 cadmium sulfate (CdSO_4) solution to form cadmium sulfide (CdS). The latter compound is then measured iodometrically. An impinger containing hydrogen peroxide is included to remove SO_2 as an interfering species.

This method is applicable for the determination of the hydrogen sulfide content of fuel gas streams at petroleum refineries.

407.7 METHOD 17 - DETERMINATION OF PARTICULATE EMISSIONS FROM STATIONARY SOURCES (IN-STACK FILTRATION METHOD)

The amount of particulate matter found in an effluent gas stream is largely a function of temperature. Therefore, to prevent variability in particulate matter emission regulation, variables such as temperature and even pressure must be clearly defined. Where Method 5 is specified in an applicable subpart of the standards, particulate matter is defined with respect to temperature. Method 5 establishes 250° F as a nominal reference temperature. However, where particulate matter concentrations are known to be independent of temperature (over the normal range for a particular source category), it is preferable to eliminate the heated glass sample probe and heater filter holder and sample at stack temperature.

407.7.1 Principle and Applicability

Particulate matter is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at stack temperature. The particulate mass is determined gravimetrically after removal of uncombined water.

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This method applies to the determination of particulate emissions from stationary sources for determining compliance with New Source Performance Standards, only when specifically provided for in an applicable subpart of the standards. This method is not applicable to stacks that contain liquid droplets or are saturated with water vapor. In addition, this method shall not be used as written if the projected cross-sectional area of the probe extension-filter holder assembly covers more than 5 percent of the stack cross-sectional area.

407.8 METHOD 18 - MEASUREMENT OF GASEOUS ORGANIC COMPOUND EMISSIONS BY GAS CHROMATOGRAPHY

In this method, the major components of a gas mixture are separated by gas chromatography (GC) and individually quantified by flame ionization, photoionization, electron capture, or other appropriate detection principles. The retention times of each separated component are compared with those of known compounds under identical conditions. The laboratory analyst can then confirm the identity and approximate concentrations of the organic emission components. The analyst then purchases commercially available standard mixtures to calibrate the GC under identical conditions to those of the samples. The analyst also then determines the need for sample dilution to avoid detector saturation, gas stream filtration to eliminate particulate matter, and prevention of moisture condensation.

407.8.1 Principle and Applicability

Total gaseous organic compounds in a gas mixture are separated by gas chromatography (GC) and individually quantified by flame ionization, photoionization, electron capture, or other appropriate detection principles.

This method is designed to measure gaseous organics emitted from an industrial source. While designed for ppm level sources, some detectors are quite capable of detecting compounds at ambient levels, e.g., ECD, ELCD, and helium ionization detectors. Some other types of detectors are evolving such that the sensitivity and applicability may well be in the ppb range in a few years. This method will not determine compounds that are: 1) polymeric (have high molecular weight); 2) can polymerize before analysis; or 3) have very low vapor pressures at stack or instrument conditions.

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407.9 METHOD 20 - DETERMINATION OF NITROGEN OXIDES, SULFUR DIOXIDE, AND DILUENT EMISSIONS FROM STATIONARY GAS TURBINES

407.9.1 Principle and Applicability

A gas sample is continuously extracted from the exhaust stream of a stationary gas turbine; a portion of the sample stream is conveyed to instrumental analyzers for determination of NO_x and diluent content. During each NO_x and diluent determination, a separate measurement of SO_2 emissions is made, using Method 6 or its equivalent. The diluent determination is used to adjust the NO_x and SO_2 concentrations to a reference condition.

This method is applicable for the determination of nitrogen oxides (NO_x), sulfur dioxide (SO_2), and a diluent gas (either O_2 or CO_2), emissions from stationary gas turbines. For the NO_x and diluent concentration determinations, this method includes: 1) Measurement system design criteria; 2) Analyzer performance specifications and performance test procedures; and 3) Procedures for emissions testing.

407.10 METHOD 21 - DETERMINATION OF VOLATILE ORGANIC COMPOUND LEAKS

407.10.1 Principle and Applicability

A portable instrument is used to detect VOC leaks from individual sources. The instrument detector type is not specified, but it must meet the specifications and performance criteria contained in Section 3, Apparatus. A leak definition concentration based on a reference compound is specified in each applicable regulation. This procedure is intended to locate and classify leaks only, and is not to be used as a direct measure of mass emission rates from individual sources.

This method applies to the determination of volatile organic compound leaks from process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps, and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals.

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408 MODIFIED METHOD 5 METHODS

408.1 METHOD 201 - PM₁₀ EXHAUST GAS RECYCLE METHOD

408.1.1 Principle and Applicability

A gas sample is isokinetically extracted from the source. An in-stack cyclone is used to separate PM greater than PM₁₀, and an in-stack glass-fiber filter is used to collect the PM₁₀. To maintain isokinetic flow rate conditions at the tip of the probe and a constant flow rate throughout the cyclone, a clean, dried portion of the sample gas at stack temperature is recycled into the nozzle. The particulate mass is determined gravimetrically after removal of uncombined water.

This method applies to the in-stack measurement of particulate matter (PM) emissions equal to or less than an aerodynamic diameter of nominally 10 μ (PM₁₀) from stationary sources. The EPA recognizes that condensible emissions not collected by an in-stack method are also PM₁₀, and that emissions that contribute to ambient PM₁₀ levels are the sum of condensible emissions and emissions measured by an in-stack PM₁₀ method, such as this method or Method 201A. Therefore, for establishing source contributions to ambient levels of PM₁₀, such as for emission inventory purposes, EPA suggests that source PM₁₀ measurement include both in-stack PM₁₀ and condensible emissions. Condensible emissions may be measured by an impinger analysis in combination with this method.

408.2 METHOD 201A - DETERMINATION OF PM₁₀ EMISSIONS (CONSTANT SAMPLING RATE PROCEDURE)

408.2.1 Principle and Applicability

A gas sample is extracted at a constant flow rate through a in-stack sizing device, which separates PM greater than PM₁₀. Variations from isokinetic sampling conditions are maintained within well-defined limits. The particulate mass is determined gravimetrically after removal of uncombined water.

This method applies to the in-stack measurement of particulate matter (PM) emissions equal to or less than an aerodynamic diameter of nominally 10 μ (PM₁₀) from stationary sources. The EPA recognizes that condensible emissions not collected by an in-stack method are also PM₁₀, and that emissions that contribute to ambient PM₁₀

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levels are the sum of condensible emissions and emissions measured by an in-stack PM_{10} method, such as this method or method 201. Therefore, for establishing source contributions to ambient levels of PM_{10} , such as for emissions inventory purposes, EPA suggests that source PM_{10} measurement include both in-stack PM_{10} and condensible emissions. Condensible emissions may be measured by an impinger analysis in combination with this method.

408.3 METHOD 202 - DETERMINATION OF CONDENSIBLE PARTICULATE EMISSIONS FROM STATIONARY SOURCES

408.3.1 Principle and Applicability

The condensible particulate matter (CPM) is collected in the impinger portion of a Method 17 type sampling train. The impinger contents are immediately purged after the run with nitrogen (N_2) to remove dissolved sulfur dioxide (SO_2) gases from the impinger contents. The impinger solution is then extracted with methylene chloride ($MeCl_2$). The organic and aqueous fractions are then taken to dryness and the residue weighed. The total of both fractions represents the CPM.

This method applies to the determination of condensible particulate matter (CPM) emissions from stationary sources. It is intended to represent condensible matter as material that condenses after passing through a filter and as measured by this method. This method may be used in conjunction with Method 201 or 201A if the probes are glass-lined. This method may also be modified to measure material that condenses at other temperatures by specifying the filter and probe temperature. A heated Method 5 out-of-stack filter may be used instead of the in-stack filter to determine condensible emissions at wet sources.

409 TOXIC AIR CONTAMINANT (TAC) TEST METHODS

The ARB has developed twenty-six test methods for determining emissions of Toxic Air Contaminants from stationary sources, which are listed below. Complete versions of these methods can be found at <http://www.arb.ca.gov/testmeth/vol3/vol3.htm>.

- Method 12 - Determination of Inorganic Lead Emissions from Stationary Sources
- Method 13A - Determination of Total Fluoride Emissions from Stationary Sources (SPADNS Zirconium Lake Method)

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- Method 13B - Determination of Total Fluoride Emissions from Stationary Sources (Specific Ion Electrode Method)
- Method 101 - Determination of Particulate and Gaseous Mercury Emissions from Chlor-Alkali Plants - Air Streams
- Method 101A - Determination of Particulate and Gaseous Mercury Emissions from Sewage Sludge Incinerators
- Method 104 - Determination of Beryllium Emissions from Stationary Sources
- Method 106 - Determination of Vinyl Chloride Emissions from Stationary Sources
- Method 401 - Determination of the Weight Percent of Volatile Organic Compounds in Waste Products (Gravimetric Purge and Trap)
- Method 410A - Determination of Benzene from Stationary Sources (Low Concentration Gas Chromatographic Technique)
- Method 410B - Determination of Benzene from Stationary Sources (High Concentration Gas Chromatographic Technique)
- Method 421 - Determination of Gaseous Chloride and Fluoride Emissions from Stationary Sources
- Method 422 - Determination of Volatile Organic Compounds in Emissions from Stationary Sources
- Method 423 - Determination of Particulate and Gaseous Inorganic Arsenic Emissions from Stationary Sources
- Method 424 - Determination of Inorganic Cadmium Emissions from Stationary Sources
- Method 425 - Determination of Total Chromium and Hexavalent Chromium Emissions from Stationary Sources
- Method 426 - Determination of Cyanide Emissions from Stationary Sources
- Method 427 - Asbestos Emissions
- Method 428 - Determination of Polychlorinated Dibenzo-p-Dioxin (PCDD), Polychlorinated Biphenyl (PCB) Emissions from Stationary Sources
- Method 429 - Determination of Polycyclic Aromatic Hydrocarbon (PAH) Emissions from Stationary Sources
- Method 430 - Determination of Formaldehyde and Acetaldehyde in Emissions from Stationary Sources
- Method 431 - Determination of Ethylene Oxide Emissions from Stationary Sources

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- Method 432 - Determination of Dichloromethane and 1,1,1-Trichloroethane in Paints and Coatings
- Method 433 - Determination of Total Nickel Emissions from Stationary Sources
- Method 434 - Determination of Chlorine in Unheated Air
- Method 435 - Determination of Asbestos Content of Serpentine Aggregate
- Method 436 - Determination of Multiple Metals Emissions from Stationary Sources

410 CONTINUOUS ANALYZING

The manual reference test methods discussed above provide valuable source information, however, the data may not be representative of day-to-day operating conditions. The lead time allowed for planning and preparation prior to a manual source test gives the source additional time to optimize process operation and/or to adjust control equipment performance. For this reason, the source test results obtained may not be a true representation of the actual source process performance. As a result, the U.S. EPA has promulgated many continuous emissions monitoring (CEM) requirements for stationary sources. The use of CEMs provide the information necessary for the air pollution control agency to determine whether the equipment and procedures used are operating efficiently and controlling excess emissions. Federal requirements have focused mainly on the continuous measurement of gases such as sulfur dioxide and nitric oxides, and flue gas opacity.

Continuous emission monitoring systems include a set of equipment and activities to determine and report emission levels of air pollutants. The instrumentation and procedures used for CEMs are driven by regulations, which in turn are based upon current emissions monitoring technology. Local air pollution control agencies should provide sources with the appropriate regulatory and reporting requirements which should be updated as technology and requirements change.

CEM data is important for both the regulatory agencies and the regulated industry. The main use is for the detection and reporting of excess emissions, however, the reports are also then used to:

- Determine whether or not the source is utilizing appropriate operation and maintenance practices,

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- Monitor process data during less than optimal operating conditions and provide emission information to the regulatory agency,
- Provide data to be used for compliance determination, and
- Verify the sources ability to comply with emission standards.

For additional, more detailed information on CEMs, please refer to the ARB, Compliance Assistance Program, Continuous Emissions Monitoring technical manual.

410.1 PROGRAMS REQUIRING CEMS

Continuous emission monitoring is required in many programs and covers an increasing number of sources and source categories. One of the largest continuous emission monitoring programs is the U.S. EPA New Source Performance Standards (NSPS). Many subparts of the regulation require sources to install, calibrate, maintain, and operate continuous emission monitors. These requirements primarily affect newly constructed sources, however, significant modifications of a source may trigger the application of NSPS rules. NSPS subparts can require direct compliance CEMs or compliance indicating CEMs. **Table 410.1** and **Table 410.2** lists NSPS monitoring requirements.

410.1.1 Acid Deposition

The Acid Rain Program, which prevents the adverse effects of acidic deposition by setting emission limitations to reduce precursor emissions, applies to fossil fuel fired electric utility boilers and turbines. The CEM regulations (40 CFR 75) apply to existing as well as new sources. The Acid Rain Program regulations limit the allowable emission of SO₂, NO_x, CO₂, and opacity and also allow the trading of SO₂ emissions allowances. Oxygen, carbon dioxide, stack gas velocity and pollutant concentration must be monitored to obtain SO₂ and NO_x mass emission data.

410.1.2 NESHAPS

Four subparts of the NESHAP (40 CFR 61), which have the potential to emit hazardous air pollutants, require CEMs. **Table 410.3** lists the NESHAPs monitoring requirements

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Table 410.1 Direct Compliance NSPS Monitoring

NSPS Subpart	Affected Facility	Direct-Compliance Monitor	Test Method	Averaging Period
Da	Electric Utility Steam Generator >73 MW heat input (250 million BTU/hr) a) Solid Fossil Fuel b) Liquid Fossil Fuel c) Gaseous Fossil Fuel	SO ₂ , NO _x SO ₂ , NO _x SO ₂ (except when burning only natural gas), NO _x	Method 6, 7 Method 6, 7 Method 100	30 Day Rolling 30 Day Rolling 30 Day Rolling
Db	Industrial-Commercial Institutional Steam Generators >29 MW (100 million BTU/hr)	SO ₂ , NO _x (except burning low-N ₂ Fuels)		30 Day Rolling
Dc	Industrial-Commercial Institutional Steam Generators >29 MW (10 million BTU/hr) and <29 MW (100 million BTU/hr)	SO ₂		30 Day Rolling
Ea	Municipal Waste Combustor >225 Mg/day (250 T/day)	SO ₂ NO _x CO		24 Hour Geometric 24 Hour Arithmetic 4 Hour Block Arithmetic (except mass burn rotary waterwall; 24 hour arithmetic)
J	Petroleum Refineries: FCC Catalyst Regenerator	SO ₂ , O ₂		7 Day Rolling
P	Primary Copper Smelters: Roaster, Smelter Furnace, or Converter (during compliance tests)	SO ₂		6 Hour
Q	Primary Zinc Smelters: Roaster (during compliance tests)	SO ₂		2 Hour
R	Primary Lead Smelter: Sintering Machine, Electric Furnace, or Converter (during compliance tests)	SO ₂		2 Hour
GG	Stationary Gas Turbines	NO _x (during performance tests, at other times water-to-fuel ratio indicates compliance)		N/A
RRR	Synthetic Organic Chemical Manufacturing Industry Reaction Processes)	TOC		3 Hour
SSS	Magnetic Tape Coating Facilities	TOC		3 Day Rolling
Any	Any	Opacity (source owners may submit opacity monitor data for direct compliance during performance test)	Method 9	6 minute

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Table 410.2 Compliance Indicating NSPS Monitoring

NSPS Subpart	Affected Facility	Compliance Indicating Monitor	Averaging Period	Test Method
D	Fossil Fuel Fired Steam Generator >73 MW (250 million BTU/Hr)	Opacity SO ₂ NO ₂	6 Minute 3 Hour 3 Hour	Method 9 Method 6 Method 7
Da	Electric Utility Steam Generator > 73 MW (250 million BTU/Hr)	Opacity	6 Minute	Method 9
Db	Industrial-Commercial Institutional Steam Generator >29 MW (100 million BTU/Hr)	Opacity	3 Hour 6 Minute 30 Day Rolling	Method 9 Method 9 CEMs (direct compliance during performance tests)
Dc	Industrial-Commercial Institutional Steam Generator >29 MW (10 million BTU/Hr) and <29 MW (100 million BTU/Hr)	Opacity	6 Minute	Method 9
Ea	Municipal Waste Combustor >225 Mg/Day (250 T/day)	Opacity	6 Minute	Method 9
F	Portland Cement Plants: Cement Kiln and Clinker Cooler	Opacity	6 Minute	Method 9
G	Nitric Acid Plants	NO _x	3 Hour	Method 7
H	Sulfuric Acid Plants	SO ₂	3 Hour	Method 6
J	Petroleum Refineries: Catalytic Cracking Unit Fuel Gas Combination Unit Claus Sulfur Recovery Unit	Opacity SO ₂ or H ₂ S SO ₂ and O ₂ TRS and O ₂	6 Minute 1 Hour 3 Hour 12 Hour	Method 9 Method 10 Method 6 or 11 Method 6 Method 15
P	Primary Copper Smelter: Dryer Roaster, Smelting Furnace, or Converter	Opacity SO ₂	6 Minute 6 Hour	Method 9 CEMs (direct compliance during performance test)
Q	Primary Zinc Smelter: Sintering Machine Roaster	Opacity SO ₂	6 Minute 2 Hour	Method 9 CEMS (direct compliance during performance test)

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Table 410.2 Compliance Indicating NSPS Monitoring (cont.)

NSPS Subpart	Affected Facility	Compliance Indicating Monitor	Averaging Period	Test Method
R	Primary Lead Smelters: Blast Furnace, Dross Reverbatory Furnace, or Sintering Machine Discharge End Sintering Machine, Electric Furnace, or Converter	Opacity SO ₂	6 Minute 2 Hour	Method 9 CEMS (direct compliance during performance test)
Z	Ferroalloy Production Facility: Submerged Electric Arc Furnace	Opacity	6 Minute	Method 9
AA	Steel Plants: Electric Arc Furnaces (1974-1983)	Opacity	6 Minute	Method 9
AAa	Steel Plants: Electric Arc Furnaces (1983 and after)	Opacity	6 Minute	Method 9
BB	Kraft Pulp Mills: Recovery Furnace Lime Kiln, Digester, Brown Stock Washer, Evaporator, Condensate Stripper	Opacity TRS TRS	6 Minute 12 Hour 12 Hour	Method 9
CC	Glass Manufacturing Plants: Melting Furnace	Opacity	6 Minute	Method 9
HH	Lime Manufacturing Plants: Lime Kiln	Opacity (except when using a wet scrubber)	6 Minute	Method 9
NN	Phosphate Rock Plants: Dryer and Calciner	Opacity (except when using a wet scrubber) Opacity	6 Minute 6 Minute	Method 9
FFF	Vinyl and Urathane Coating and Printing: Rotogravure Printing	VOC	3 Hour	Method 25A
LLL	Onshore Natural Gas Processing: Sulfur Recovery Oxidation Control or Reduction Control Plus Incineration Reduction	SO ₂ or SO ₂ and TRS	24 Hour	Method 6 or Method 6 and 16A Method 15
UUU	Calciners and Dryers in Mineral Industries	Opacity	6 Minute	Method 9

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410.1.3 State Implementation Plan Monitoring

Requirements listed in 40 CFR 51 stipulate that each SIP contain legally enforceable procedures requiring certain categories to continually monitor emissions. The affected source categories, performance specifications and reporting requirements are listed in 40 CFR 51 Appendix P.

Table 410.3 Neshap Monitoring

NESHAP Subpart	Affected facility	Monitor Required	Averaging Period	Test Method
F	Ethylene Dichloride Purification Oxychlorination Reactor Vinyl Chloride Plant PVC Reactor Mixing, Weighing, and Holding Containers Control Systems to which Reactor and Fugitive Emissions are Ducted	Vinyl Chloride	3 Hour	Method 106
N	Glass Melting Furnace Opacity	Opacity	6 Minute	Method 108
O	Copper Converter	Opacity	1 Hour	Method 5
P	Metallic Arsenic Production and Arsenic Trioxide Plants	Opacity	6 Minute	Inspection, Maintenance, and Housekeeping Plan

410.1.4 Permits

Continuous emission monitors can be required by various types of permits and simultaneously by regulation (NSPS, SIP, state and local requirements). Permit monitoring requirements may be more stringent than federal monitoring regulations. Types of permits that may require CEMs are Prevention of Significant Deterioration permits, Title V permits and State and District permits.

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410.1.5 RCRA Hazardous Waste Incineration

The Resource Conservation and Recovery Act (RCRA) has several requirements for continuous emission monitoring for those facilities that burn hazardous wastes. Incinerators (covered by 40 CFR 264), and boilers and industrial furnaces (covered by 40 CFR 266), are allowed to burn hazardous waste. Stack gas velocity and CO are measured in incinerators, and CO, O₂ and hydrocarbons are monitored in boilers and industrial furnaces (BIF). Some RCRA sources are required to conduct reference method testing to minimize excess emissions of toxic compounds, chlorinated compounds, and metals.

410.1.6 Discretionary Monitoring Programs

Discretionary authority is given to air control agencies in order to include continuous monitoring into their regulatory process. Examples of discretionary programs can include variances, orders, agreements and permits.

410.1.7 Implicit Programs

Guideline documents developed by the regulatory agency may contain implicit programs listing specific information pertaining to CEM installation and operation. Because these documents are not subject to agency rule-making procedures, they must be carefully written so as to not place additional requirements on facilities.

410.2 TYPES OF CEM SYSTEMS

Continuous emission monitors are divided into three general classes: 1) Extractive, 2) In-situ, and 3) Predictive. Each class contains further division into more specific monitoring types. **Table 410.4** shows the CEM classes and divisions.

410.2.1 Extractive systems

There are two different types of extractive monitoring systems: those at the source level and those that are diluted. Source level extractive systems condition the stack gases and then route them to the analyzers. Dilution systems actually dilute the stack gases with clean air before routing them to the analyzers. The advantage of extractive

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systems is that the equipment is usually at ground level, and therefore easily maintained. The disadvantage is that they are complex systems of equipment and utilize more individual pieces of equipment than the in-situ monitors.

Table 410.4 Source Monitoring Systems

Extractive Systems	Dilution	Non-Dilution (source level)
In-situ Systems	Point	Path Single pass Double pass
Predictive Systems	Used with steady-state sources	

410.2.2 In-situ Systems

In-situ CEMs analyze pollutant concentrations in place in the stack. They have fewer parts than extractive systems and so capital equipment expenses are generally lower. Maintenance costs, however, can be higher since they occur on the stack, exposed to weather. The equipment is exposed to harsher conditions, such as weather and exposure to corrosive gases and vibrations from the stack. In-situ monitoring does not condition gas such as controlling gas temperature or removing moisture. An extractive system must be used if gas conditioning is necessary.

There are two types of in-situ measurement CEM systems: point and path. Point systems measure the gas from a small point where the probe is installed in the stack. Measurement accuracy is dependent on two factors: the location of the probe and its ability to withstand stack conditions. The probe must be located at a point where the sample is representative of the stack emissions. Also, the analyzer must withstand the harsh conditions of the stack and still be able to accurately measure gases.

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Path measurement systems, or cross-stack CEMs, average the emission concentrations across the width of the stack. The actual path can be either a single pass or a double pass measurement across the stack. The double pass monitor has twice the pathlength and so is more sensitive than a single pass monitoring instrument.

Table 410.5 lists the advantages and disadvantages to in-situ and extractive systems.

410.2.3 Predictive Systems

In predictive monitoring systems (PEMs), a computer is used to predict the emissions based on measured operational and ambient parameters. In sources for which the parameters are predictable and which use homogeneous fuels, PEMs can be a viable alternative to a CEM system. A PEM system may cost less to install and operate, and may do as good a job reporting emission data as a gas analyzer CEM system. The most common type of PEM facility is the gas turbine because they use clean, well defined fuels and operate at a constant rate.

411 COMPLIANCE ASSURANCE MONITORING (CAM)

Compliance Assurance Monitoring (CAM) regulations were established in response to the Clean Air Act Amendments (CAAA) of 1990, and contain several provisions requiring major sources to conduct monitoring and make compliance certifications. CAM was developed to address the requirements of Title VII in the CAAA and is intended as the mandated enforcement and compliance certification tool. CAM rules also satisfy requirements for monitoring and compliance certification in Title V, Part 70, Operating Permits.

The CAM rule focuses on improving current monitoring requirements, and allows facilities to develop operation ranges for control equipment in order to minimize emissions and provide a reasonable assurance of compliance. A complete discussion on CAM can be found in the Continuous Emission Monitoring technical manual.

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Table 410.5 Advantages and Disadvantages of In-Situ and Extractive Systems

System Type	Advantages	Disadvantages
Path in-situ	Fast response time No sample transport or conditioning Gas measured on wet basis Simple, less expensive installation Less equipment to buy and maintain	Potential interference by particulate or droplets Gas measured on wet basis moisture content must be assumed for dry basis reporting Sometimes cannot locate equipment downstream of sorbent injection or spray dryer systems Analyzers exposed to harsh operating conditions and vibrations Limited choice of analyzer Cannot calibrate analyzer when process is operating
Point in-situ	Fast response time No sample transport or conditioning Gas measured on wet basis Simple, less expensive to buy and maintain	Representative sample difficult to obtain in some situations Gas measured on wet basis Vibration sensitive Access for maintenance can be difficult Limited choice of analyzer
Source level extractive	Allows widest selection of analyzer technologies Can analyze at ambient conditions for which more reference data is available Can combine more than one analyzer (e.g. GC and FID) Can remove interfering substances before measurement Gas measured on dry basis Analyzers can be installed in an accessible, clean environment Multiprobe capability for representative sample	Sample transport and conditioning system is expensive to install and operate and has high power requirements Sample transport and conditioning system has potential for pluggage, leaks, and condensation problems (both water and acid) Gas conditioning is often required Gas measured on dry basis May inadvertently remove substances of interest Condensed water and/or filter residues may need to be analyzed
Dilution extractive	Wide selection of analyzers Can analyze at ambient conditions One dilution system can serve several analyzers Analyzers can be installed in an accessible, clean environment Gas measured on wet basis Multiprobe capability Heated sample lines and moisture removal systems not necessary	Measurement accuracy and data precision problems may occur with highly diluted samples Dilution system may not work on high moisture flue gas Gas is measured on a wet basis; this may not be a problem if CO ₂ is used as the dilution gas Requires additional calibration for the dilution system

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This section presents information regarding how to conduct a stationary source test, from project inception and planning, through its completion with the source test report. This is based on a "Method 5" source test for particulate matter for several reasons. Built into a Method 5 source test, either directly or by reference, are the procedures and equipment specifications necessary to determine proper stack sampling points/traverses (Method 1), stack gas velocity and flow rate (Method 2), gas analysis and molecular weight (Methods 3 and/or Method 100), moisture content (Method 4) and particulate matter and report writing. Most other source test methods, especially those for determining emissions of toxic air contaminants, are based on Method 5 and are, in fact, referred to as "Modified Method 5" procedures. Understanding how to perform or observe/audit a Method 5 test is the best foundation for learning how to perform or observe most other source test methods, from metals to dioxins.

501 INTRODUCTION

Included in this section is information designed to assist the prospective source tester in organizing and performing a source test project. What is not offered here can be found in the test methods. Also included are the steps, for both the source tester and the auditor/observer, to guide them successfully through each phase of the test project. These are based on information and data forms obtained from: ARB Stationary Source Test Methods; US EPA Stationary Source Test Methods and related documents; and experienced source test personnel. Chapter 500 is further divided into two sections; Performing the Test and Observing the Test, and includes the following topics:

- Test Objectives
- Test Design
- Pretest Site Visit
- Source Test Protocol
- Securing Laboratory Services
- Source Test Equipment
- Performing The Source Test
 - Equipment Setup
 - Preliminary Velocity Traverse
 - Determining Moisture Content
 - Determining Stack Gas Molecular Weight
 - Calculating Nozzle Size
 - Assembling Sampling Train/Marking Probe
 - Conducting Leak Test

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- Preparing Data Sheets
- Method 5 Train Operation
- Monitoring Process Data
- Continuous Emissions Monitoring
- Sample Recovery
- Calculations
- Report Writing
- Quality Assurance
- The Role of the Observer
- Observation Procedures

Table 502.1 shown on the following pages is a useful guideline for planning and performing a Method 5 test.

502 TEST OBJECTIVES

Source testing is used to provide necessary information to determine control equipment efficiency, process control effectiveness, and process economics. It is used to determine compliance with emissions regulations. Source testing is therefore very useful in obtaining needed information to the environmental control agency as well as to industry.

502.1 PURPOSE OF TEST

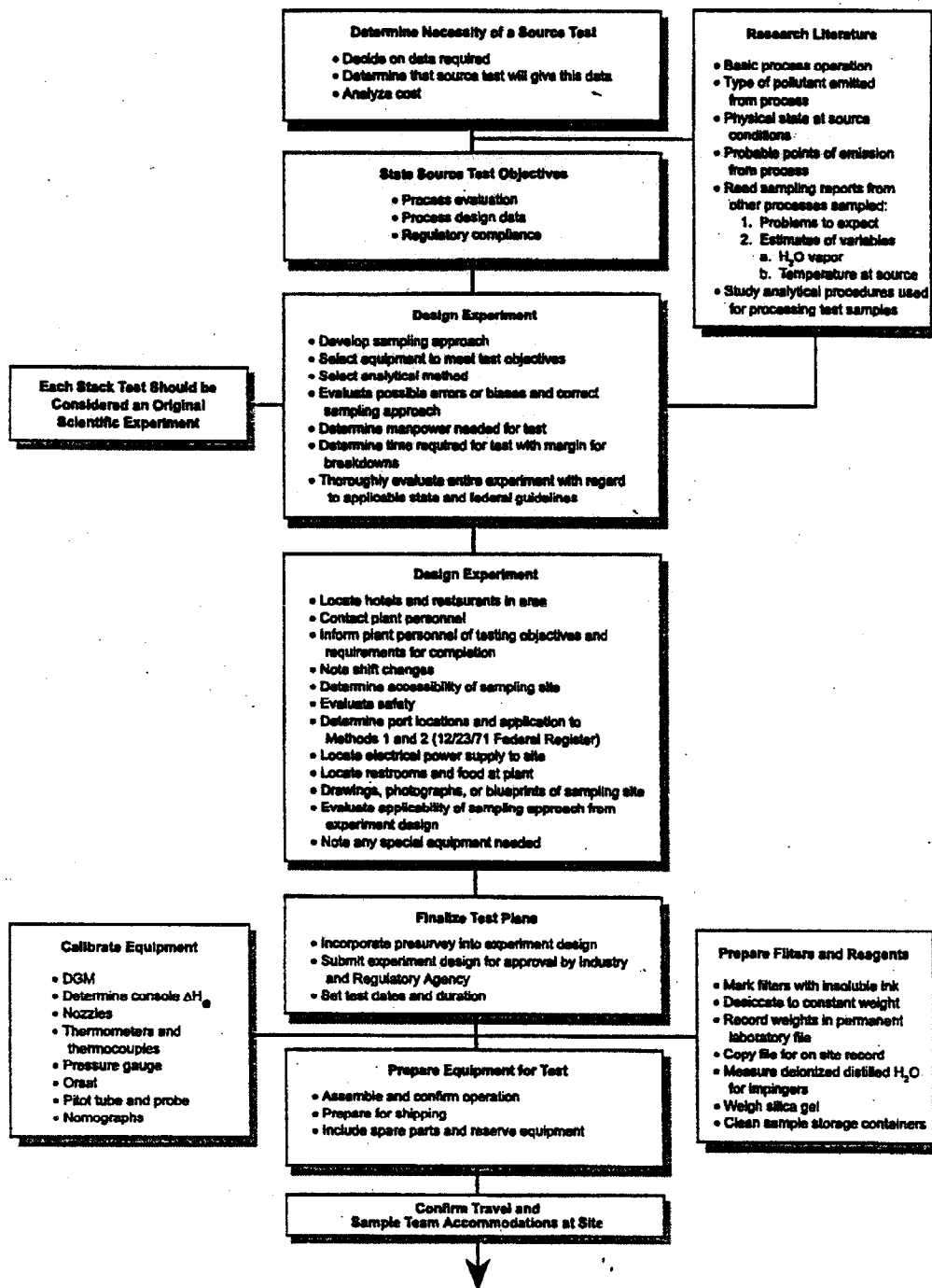
The first step in performing a source test is deciding on the purpose of the test. The purpose will outline what sampling methods are to be used, who shall perform the testing, what the operational conditions will be, and many other factors involved. The test methods used are decided by and dependent upon the control agency requiring the test. Federally required testing and NSPS sources will follow the EPA methods, while ARB methods are required if the tests are needed to satisfy State rules or regulations. If the facility must meet both EPA and ARB requirements as well as the district requirements, the same raw source test data can usually be used in whatever terms are needed.

Source tests may be used to determine the efficiency of control equipment, to monitor hazardous waste destruction and removal efficiency, to certify continuous emission monitors, and for other monitoring purposes, as well as for compliance testing and to know emission rates. Additional testing purposes may require specific testing parameters, such as simultaneous sampling at multiple locations, longer sampling times, or

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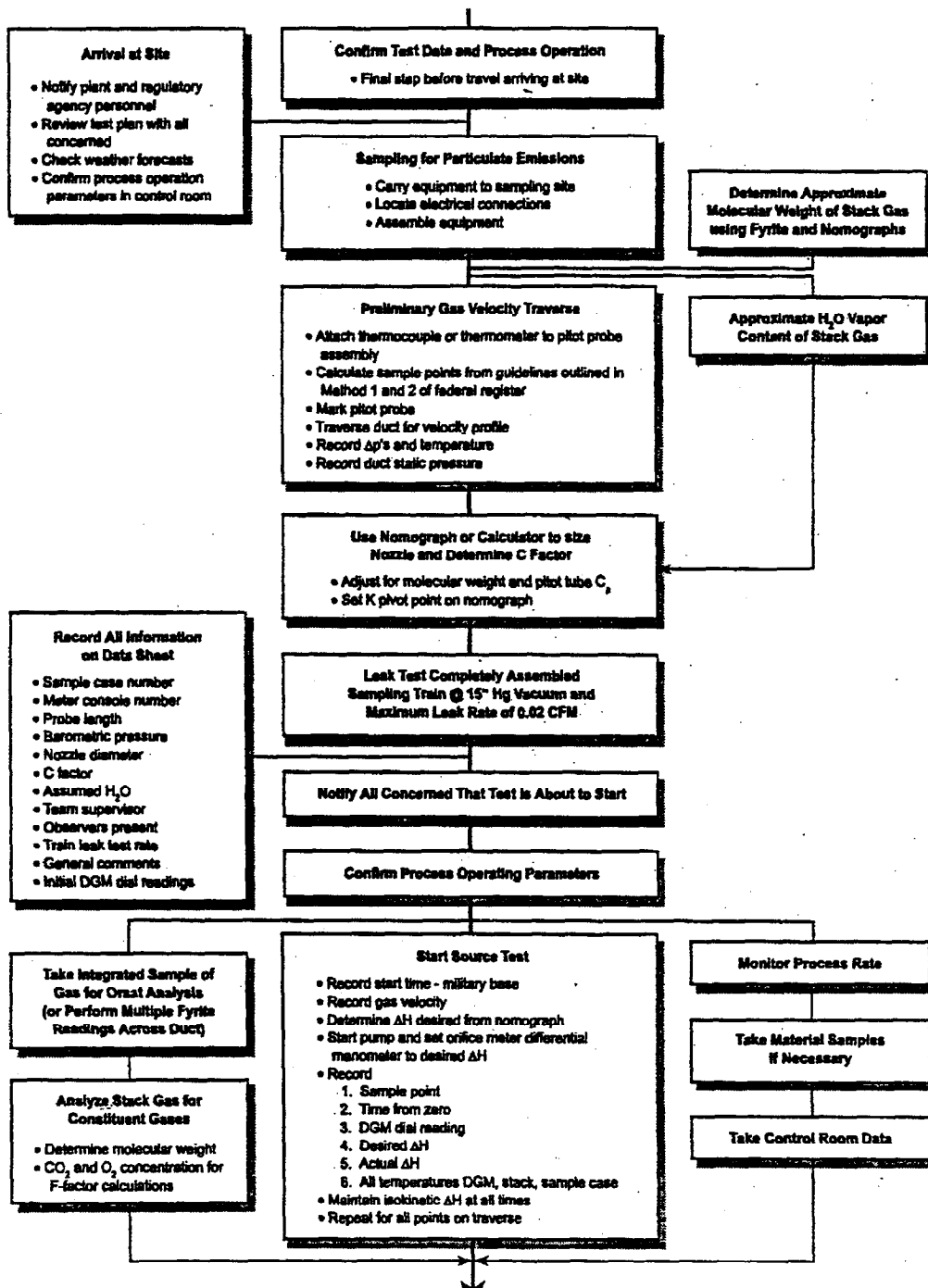
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Table 502.1 Planning and Performing a Method 5 Test



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Table 502.1 Planning and Performing a Method 5 Test (continued)



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more sampling runs. Specific emission parameters should be acknowledged prior to testing in the case of permit requirements, NSPS provisions, and specific data reporting terms required.

502.2 DATA REQUIREMENTS

Prior to testing, there are several important considerations to be decided regarding test data.

Primarily, the source tester needs to know what process and control data is available. Control room personnel can familiarize the tester and test observer with the layout of the displays, the information available, and the data format. Usually a computer printout is available to report important data. Also, a specific printout may be designed for the test which contains the necessary information in a logical format. Information may be gathered, integrated, and printed out on a schedule coinciding with the scheduled source test.

Next, the process and control data needs to be reviewed so only the appropriate required data is gathered; not all of the data available in the control room may be pertinent to the test.

The process and control device data that documents continued compliance must be reported. Data available in the control room may be needed for future reference and to ensure the process is operating in continuing compliance.

Confidentiality is an important part of data gathering decision making, and should be considered when deciding what data is to be included in the source test report. Some data is considered to be confidential by the source and should not be recorded unless truly required. If it is required, the data should be handled carefully and in accordance with agency policies.

502.3 PROCESS EVALUATION

Deciding what process and facility operation parameters to use is an important part of a successful source test. In planning the process and facility operation parameters, the pretest serves as a forum to decide the important operational restrictions such as process rate, temperature and materials.

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502.3.1 Operation

If the operation is a batch operation, the testing schedule should be coordinated with the process schedule. A process may be a random or cyclic batch, or intermittent. If the process is non-continuous, work may need to be saved up in order to perform the source test. A source test may have a significant impact on a facility, so consideration to the needs of the facility and its customers is very important.

502.3.2 Pollutants Emitted

Before the source test date, the source tester should review the facility files to determine what pollutants need to be tested and how the testing should be completed. Also, it is important to review all operating permits issued to the facility. Permits often specify what is to be sampled, how often, and what methods are to be used. Many pollutants emitted may require some modification to the standard sampling procedures. For each different pollutant tested, rules and regulations may change or emission limits will vary as a function of process parameters. It is a good idea to get an accurate determination of process rates and pollutant emission rates prior to testing, and to document these rates in the test plan so there is agreement on the compliance criteria.

502.3.3 Probable Sampling Locations

The proper sampling site must be selected in order to obtain a representative measurement of the pollutant emissions and the volumetric flow rate from the source. Essential considerations include safety, accessibility, sampling equipment clearance, electrical power access and personnel exposure to weather or heat from the process. Additional concerns might be those of hazardous gas presence, inhalation hazards, explosive hazards, confined space hazards and/or the additional use of protective equipment.

There are minimum state OSHA requirements for constructing sampling ports at a facility to ensure a safe, accessible area for sampling personnel. These include requirements for a suitable work platform, stairway, caged ladder, or other safe and easy port access, electrical outlets, guardrails and clearances. State OSHA information may be reviewed at www.dir.ca.gov/DOSH.

Also, from Method 1, the EPA requires that a sampling port must be located at a point in the stack or ductwork that is eight duct diameters downstream from a distur-

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bance, and two duct diameters upstream from a flow disturbance. Each of the above mentioned issues must be considered when determining the most appropriate sampling site for the test.

502.3.4 Operating Permit

Each stationary source will receive a permit to operate their facility from the local air pollution control district. The ARB Criteria for Assessing District Enforcement and Permitting Program Adequacy requires that the districts incorporate source emissions testing into their permits and programs. A permit will outline specific emissions testing for a source, based upon current rules, regulations, emissions standards and process controls. Reviewing the facility permit is essential when planning a source test.

502.3.5 Previous Test Reports

Source data obtained prior to the current source test is sometimes useful in order to gain a better knowledge of the source process, and to determine the analyzer range and applicable calibration gases. It may also show if the source is capable of operating and staying in compliance over a period of time. Only the data obtained during the actual source test however, must be reported as part of the current test.

503 TEST DESIGN

Each source test is an original scientific study and should be organized and executed with the same care as any analytical test. A well designed test plan incorporates sampling equipment, techniques and analysis in an integrated system designed to meet the test objective.

A source test should be designed to measure all stack gas variables that are used in evaluating emissions source characteristics. When this is used as the test objective, and specifically designed techniques and equipment are used, the probability of obtaining a representative sampling of the source emissions is increased. Developing an effective source test requires knowledge of sampling procedures, as well as an understanding of the process operations of the facility being tested.

The test design should be a unified program that organizes all areas from test objectives to sample results and analysis. The source test is based upon a sampling procedure that can collect the greatest amount of data. The sampling equipment is then selected to support the sampling procedure. After the sampling has been performed,

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the analysis of the sample must be viewed as an integral factor in the overall test design. When the design is completed, it should then be reviewed, modified, and agreed upon by industry and regulatory personnel prior to testing. In addition, a test matrix should be included in the test plan that identifies each test parameter, the method to measure that parameter, and the minimum sampling volume requirements specified in the methods. It is important to understand and fulfill these requirements or the test could be disqualified.

503.1 REGULATORY REQUIREMENTS

When testing for regulatory compliance, the test must be designed in order to produce data that is accurate and useful to the regulatory agency. The purpose for the test should be clearly understood during the test design phase, so that the data reported meets local, state, and/or federal requirements.

503.2 SAMPLING METHODS

Depending on the source test objectives, a number of different sampling methods may need to be performed. The test must be designed so that the most efficient method of incorporating all necessary methods and goals are included.

503.3 ANALYTICAL METHODS

Specific analytical methods, such as gravimetric, volumetric, spectrographic, chemical, and chromatographic should be chosen in order to produce appropriate data and reports according to the source test objective.

503.4 EQUIPMENT SELECTION

The sampling equipment used during a source test is designed to facilitate the sampling procedure. Equipment should be chosen that is specifically designed with the test objective in mind. There are many competitive source test equipment suppliers available.

503.5 ESTIMATE TEST DURATION

The length of testing time is an important issue during the planning of a source test. The test duration is dependent upon many other aspects of the source test, such as

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testing techniques and equipment, as well as sampling methods required. Personnel will need breaks, food, and water, or need to be replaced depending upon the test length. Testing supplies and equipment will need to be replenished or replaced if the source test is lengthy.

503.6 PERSONNEL REQUIREMENTS

The number of personnel required to be present at a source test can vary greatly with the complexity of the testing required. Facility personnel will need to be available to orient contractors, to oversee that the correct testing is being conducted, and for safety reasons. Testing engineers and technicians are required to conduct the analytical checks as well as monitor the actual sampling. It is important for agency personnel to observe the tests if possible, however, the presence of additional people at a facility source test who are unfamiliar with the plant layout can cause added safety and equipment clearance problems, and possible accidents. Also the potential for errors increases with more human distractions or input. A survey of all personnel needing to be present at a source test should be incorporated into the source test plan and design.

504 PRE-TEST SITE VISIT

The pretest site visit or pre-test conference is probably the most important part of the source test process. Before the pre-test facility conference, the source test planner should have reviewed all files, permits, and test requirements pertaining to the source test. At the conference, all specific procedures, processes, and variables relating to the test are defined. The pre-test site visit is the time to review the plant layout, examine the access to the stack, confirm access to electrical and other utilities, and to locate any safety hazards. Facility, regulatory, and testing personnel can take time at the pre-site visit to discuss and understand the goals of the test and the test design objectives. By performing a properly planned pre-test visit, the actual source test is made easier and more efficient.

504.1 CONTACT FACILITY

The source sampling test team should contact the facility well in advance of the proposed source test date. This allows the facility plenty of time to prepare the plant for the source test. The team should report to one specific person at the facility, usually the plant manager, so that there is no confusion or communication errors during the source test period.

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504.1.1 State Objectives

The source test objectives should be clearly defined and agreed upon by the facility, source tester and regulatory personnel. This should be done prior to any actual test planning, and documented in an approved test plan.

504.1.2 State Requirements

Source tests are scheduled for many different reasons. Facilities may require a process change and conducting a source test will show current process data that can assist the source in determining what changes to make. Rules and regulations are many and varied, so the requirements of the source test must be clearly spelled out during the test planning stage.

504.2 DETERMINE ACCESSIBILITY

Source test personnel will require space for equipment, computers, and vehicles at the site. Test equipment will need to be assembled, moved through areas of the plant and lifted up the stack. All this movement not only requires more lateral space, but space for the actual movement and work area around equipment. If accessibility of the stack and work area is closely evaluated in the test planning phase, there is less chance of accidents, equipment damage, and movement problems during the actual test. **Figure 504.1** shows a probe leak test being performed on the stack platform.

504.3 EVALUATE SAFETY

Source testing is done at many different types of industrial sites and under a variety of conditions, therefore, safety is a main concern. General safety procedures should be known and practiced by all testers, although adequate practices may be quite different at each location. The source test team must be aware of safe operating procedures, and instill a safety attitude into all team members. A well thought out and implemented plan will help to insure safety awareness in the source test team. Each team member must be responsible for his/her own safety as well as that of the team.

Although knowledge and experience are the major factors in good safety practices, becoming familiar with the source and the source process will help make the source test a safe one. Also, some facilities require anyone visiting the site to attend a short safety briefing first. Some safety issues to evaluate are:

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Climbing and height hazards - Proper equipment and climbing and height safety procedures should be followed.

Explosive hazards - An inventory of any potential explosive hazards and related and precautionary measures should be noted.

Chemical hazards - Check for any potential chemical exposure hazards. Material Safety Data Sheets (MSDS) should be made available to source testers and reviewed prior to testing.

Inhalation hazards - A facility may have inhalation hazards from an accumulation of toxic gases or confined spaces. A determination needs to be made whether or not workers need respirators or breathing equipment.

Thermal hazards - Hot stacks, pipes, steam, and process equipment are all examples of thermal hazards. Knowledge of stack temperatures is important for the prevention of burn injuries during the source test.

Rotary hazards - The presence of rotating equipment such as pumps, motors, augers, or other rotating shafts must be discussed at the pretest conference.

Electrical hazards - Power and signal lines should be noted. Some facilities have power lines with high voltages and current. These lines should be avoided when working around the plant during the source test. Also, static charges can build up on stacks, equipment, or the sampling train itself.

Confined spaces - If possible, confined space entry should be avoided. However, if a confined space must be entered to perform a source test, OSHA, and facility confined space procedures must be followed. A permit to enter the confined space should be agreed upon at the pretest conference.

504.4 DETERMINE ACCESS TO STACK AND UTILITIES

The pretest conference is the best time to examine access to the stack and to electrical and other utilities. The stack platform must be sturdy enough to hold all the personnel and equipment necessary to perform the source test and be in a safe condition. The electrical supply should be appropriate for the test with no hazards present.

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The port location should be at least eight stack diameters downstream and two diameters upstream from a disturbance. As little as two stack diameters and one-half stack diameter upstream from disturbances can be used. However, non-uniform flow is more likely at these locations.

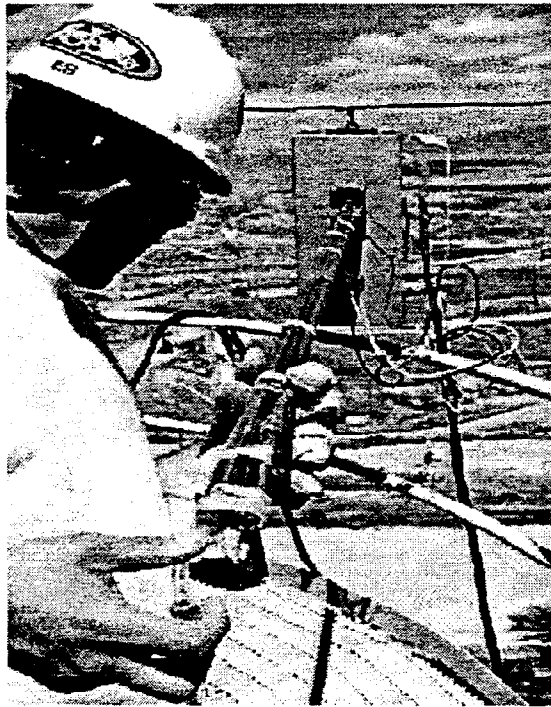


Figure 504.1 Performing a Probe Leak Test on a Platform

504.5 NOTE EQUIPMENT NEEDED

All equipment necessary for the particular test should be selected, assembled, and checked, in advance of the source test date. This includes special equipment, or equipment borrowed from the site itself, such as ladders, extension cords, lifting equipment, extensions for exhaust stacks and hardhats. The use of an equipment checklist helps ensure that the necessary equipment is made available for the source test.

504.6 CONDUCT PRELIMINARY VELOCITY TRAVERSE

At the pre-site visit, it is necessary to perform a preliminary Method 1 Test, Sample and Velocity Traverses for Stationary Sources, in order to determine the location of the sampling site and sampling points. The data obtained from this test will help

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determine access to the appropriate stack port site and any special equipment needed. Also, Method 1 can provide useful data for assembling the actual sampling train prior to the test.

504.7 MOISTURE DETERMINATION (OPTIONAL)

Use the techniques in Method 4 to obtain the moisture content of the stack flue gas. If the gas stream is not saturated, a wet bulb-dry bulb technique, or psychrometric technique, can be performed easily. First, obtain the wet bulb and dry bulb temperatures of the flue gas and then use the psychrometric chart or calculational methods to determine the moisture content. This information, as well as any data obtained prior to the test date, will help to conduct a more efficient test.

505 SOURCE TEST PROTOCOL

A source test protocol, even if not required, is encouraged, since problems can be averted prior to the sampling date. A protocol should contain at a minimum, the following information:

- Company name
- Company contact and phone number
- Source being sampled
- Emission point number
- Testing Company (consultant)
- Proposed sampling dates
- Regulation requiring sampling
- Pollutants being sampled
- Proposed sampling methods
- Proposed deviations from standard sampling methods
- Date source started operation
- Design, normal, and maximum operating level of source, if applicable
- Operating parameters to be monitored during sampling
- CEMS being certified
- Date CEMS installed
- Proposed performance specifications
- Drawing of stack with location of ports and CEMS
- How results will be calculated/reported
- Quality assurance plans/procedures

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If any changes are proposed, the protocol should be submitted prior to the pretest meeting in order to allow time for evaluation if necessary.

505.1 INCORPORATE TEST OBJECTIVES, DESIGN AND SITE VISIT INFORMATION

To assure an efficient and accurate source test, testers will need to incorporate all details covered in the previous sections of this chapter. Test objectives, test design and site visit information gathered should be included.

505.2 PREPARE TEST SCHEDULE

Develop a formal test schedule for the source test. The schedule should be detailed and include all necessary information, including when the team will depart to the test site, test equipment set-up times, lunch and break times, and when the actual testing will begin and end. The schedule will be distributed to key personnel and the plant manager so proper safety precautions may be taken.

505.3 OBTAIN TEST FACILITY AND DISTRICT APPROVAL

Source test plans must be approved by the APCD or AQMD and the source facility manager prior to scheduling. The industrial and regulatory personnel will review the test program thoroughly before approval. The protocol for the entire source test should be understood and agreed upon before the start of the actual test.

505.4 FINALIZE AND DISTRIBUTE TEST PROTOCOL

Incorporate all necessary changes to the test protocol and obtain final approval from the facility manager, source test contractors and regulatory personnel. Make sure that the completed protocol is distributed to all personnel involved in the source test.

506 SECURE LABORATORY SERVICES

A laboratory service often must be obtained for the source test, whether is it included as part of the source test team or a separate service. The laboratory must be appropriate for the specific testing required. Some tests can only be performed in very specialized labs, so it is important to do some research of laboratory services prior to

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formalizing the test. Is it important to check with the AQMD or APCD regarding any specific laboratory and sample analysis requirements.

506.1 Prepare Contract for Services

In order to be sure the necessary testing is completed, a detailed and specific contract should be developed with all laboratory services obtained. Because the laboratory analysis results may be included in litigation, the contract will be instrumental as evidence.

506.2 Create Workplan for Pre-Test, Test and Post-Test Requirements

A laboratory workplan is a good tool to clarify and outline all requirements for a particular test. It will also eliminate any unnecessary and costly laboratory procedures. The workplan, if developed properly, can prepare the lab and equipment so the sample analysis will be done smoothly and more efficiently.

506.3 Establish/Review Quality Control and Quality Assurance Procedures

A quality assurance (QA) program must be designed and reviewed with the contract lab to be sure that proper quality control (QC) procedures are being performed.

A good QA plan will address the questions of Who, What, Where, When, Why and How. The program will outline Who is in charge of What part of the plan and How the work will be done. Understanding Why the data is being collected is crucial to the success of any source test. The source test team and the lab must understand the purpose of the data collection to prevent the possibility of collecting incomplete and inaccurate data. A QA organization chart is a helpful tool and can simplify the planning and understanding of the test requirements. QA planning documents can include:

- Work and test plans
- Quality assurance plans
- Data handling protocols
- Data quality objectives
- Site selection, sampling, and analytical procedures
- Standard Operating Procedures (SOPs)
- Corrective action plans

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506.4 Create Chain of Custody Forms and Sample Labels

Chain of custody documentation should be used for all samples and data sheets. The rules of evidence require impeccable and traceable identification of all samples, as the analysis of samples can be the basis of future litigation. The observer should have in their possession sample identification, transportation, and analysis checklists, to ensure the use of the proper chain of custody procedures at the source test. Samples of these checklists can be found in Appendix C of this manual.

All sample petri dishes, impinger wash bottles, and clean-up rinse bottles should be properly marked to ensure positive identification throughout the test and analysis procedure. A unique identification number should be assigned to each container to prevent the possibility of interchange. Each sample container identification number must be recorded on the sampling and analysis data sheets.

In addition, all filters used in testing must be positively identified. All identifying marks should be placed before using. An identification number of three or more digits can be used to ensure uniqueness of a filter for many years. The ink used for marking must be indelible and unaffected by temperatures, gases, and solutions to which it will be subjected during the tests and analyses. Remember that the means of identification used must not impair the function of the filter.

506.5 Prepare Filters and Reagents

Desiccate the filters to constant weight and record the weights in a permanent laboratory file, then make a copy of the file to be used at the test site. Measure deionized, distilled water to be used in the impingers. Weigh the silica gel and record. Clean the sample storage containers.

506.6 Prepare Blanks, Spikes

Field blanks are quality-control samples which measure bias. There are several types of blanks. The lab blanks stay at the lab. Trip blanks go into the field, but remain unopened. Field blanks are opened and set aside and exposed to the same atmospheric conditions as the sorbents, resins and reagents. Field blanks, trip blanks, and the actual test samples are shipped together, upon the completion of the test, to the lab for analysis.

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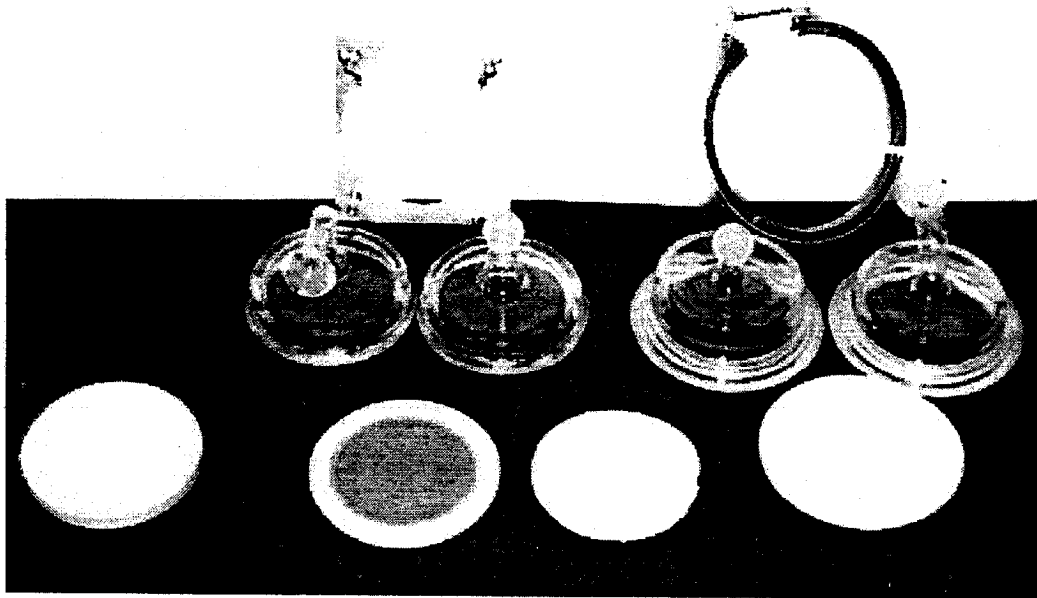


Figure 506.1 Filter Assemblies

Spikes are environmental field samples fortified with a known concentration of selected analytes to measure bias in degradation during shipping or in recovery.

507 SOURCE TEST EQUIPMENT

The test equipment must be completely assembled and checked in advance of the test date. All equipment used should be inspected and be in good working condition. Check calibration requirements to ensure that all necessary calibrations are conducted before the actual source test day.

507.1 INSPECT, TEST EQUIPMENT

The entire sampling system should be assembled as for use during the sampling experiment. This ensures proper operation of all the components and points out all possible problems that may need special attention during the test. Inspect and test all equipment in the sampling train. Improperly calibrated or uncalibrated equipment will result in errors throughout the testing procedure.

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507.2 CALIBRATE EQUIPMENT

Each piece of equipment should be calibrated following the procedures and frequency specified in the test method. Equipment calibration should be performed in the laboratory and checked just prior to using at the test site.

507.2.1 Nozzles

The probe nozzle should be made of #316 stainless steel, or quartz with a sharp, tapered leading edge, depending on the particular pollutant sampled. A taper angle equal to 30 degrees or less on the outside of the sampling nozzle will preserve a constant internal diameter. The nozzle should be a button-hook or elbow design so that the nozzle opening is below the Pitot tube sensing orifice. This is necessary for isokinetic sampling. Alternate construction materials or nozzle shapes must be approved by the administrator.

The sampling nozzle must be calibrated before use on a source test. Calibration should be done in the laboratory and checked just prior to use in the field. Inside/outside calipers are used to measure the interior nozzle diameter to the nearest 0.025 mm. The calipers are inserted as close to the edge as possible to the nozzle opening. Readings are then taken on three separate diameters and recorded. Calibration measurements must be taken three times.

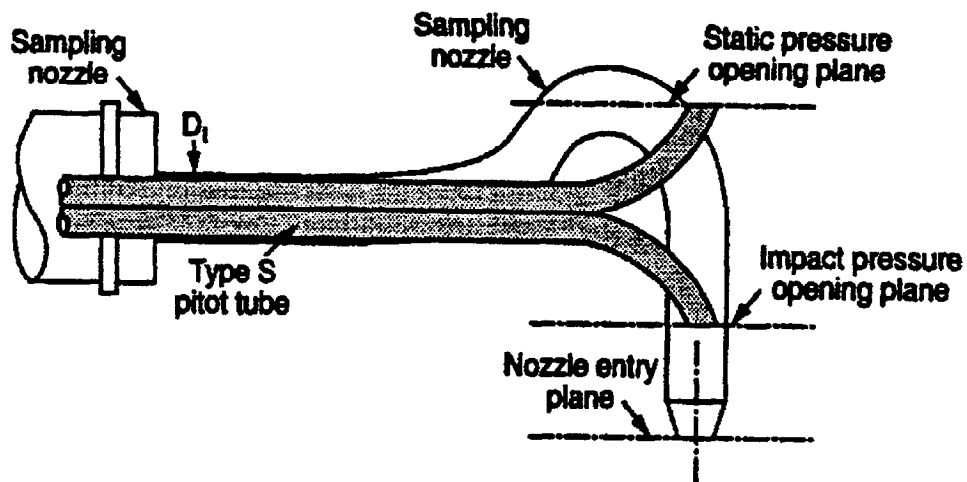


Figure 507.1 Probe Nozzle Drawing

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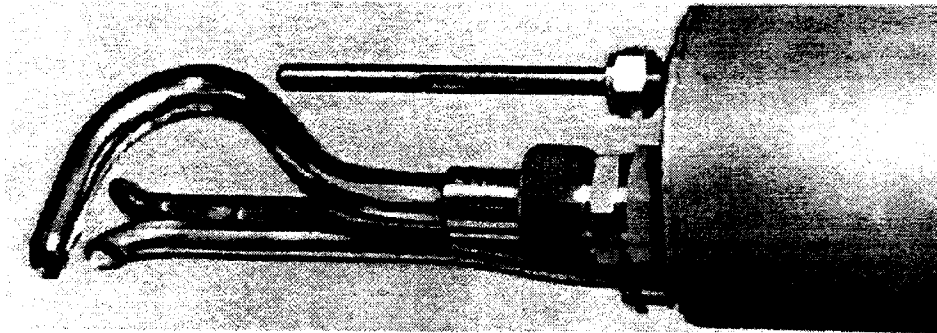


Figure 507.2 Probe Nozzle Photo

Nozzles cannot be nicked, dented, corroded, or have obvious flat places in its body. Any nozzle that is not true round must be rounded, ground to a sharp edge, and recalibrated. Calculate the nozzle diameter needed for the test from the preliminary moisture, sampling rate, and stack velocity. Once chosen for use, the calibrated nozzle should be permanently identified.

A nomograph or calculator is used to graphically solve the sampling nozzle size equation, and the isotonic rate equation. A nomograph is a device that graphically represents a formula to obtain a result. Currently, programmable calculators may be used to solve both of the following equations:

Sampling nozzle size equation:

$$D_n = \sqrt{\frac{K_D Q_m P_m}{T_m C_p (1 - B_{ws})}} \sqrt{\frac{T_s M_s}{P_s \Delta p_{est}}}$$

Where:

- D_n = nozzle diameter in inches
- Q_m = volumetric flow rate through meter (ft^3)
- P_m = absolute pressure at meter (in. Hg)
- P_s = absolute pressure at stack (in. Hg)
- T_m = absolute temperature at meter ($^{\circ}\text{R}$)
- T_s = absolute temperature at stack ($^{\circ}\text{R}$)
- C_p = pitot tube calibration coefficient
- B_{ws} = water vapor in stack gas, volume fraction
- M_s = molecular weight of stack gas, wet basis (lb/lb-mole)
- Δp = average velocity head of stack gas (in. H_2O)
- K_D = 6.0-7 metric units, 0.0358 English units.

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Isokinetic rate equation:

$$\Delta H = K_H D_n^4 \Delta H @ C_p^2 (1 - B_{ws})^2 \frac{M_d T_m P_s}{M_s T_s P_m} \Delta p$$

During the test the observer should check that the nozzle is properly installed on the probe (parallel to the pitot tube), oriented to the stack gas flow and is clean before beginning sampling.

507.2.2 Temperature Measurement Device Calibration

A Method 5 source test requires gas temperature measurements at many locations of the sampling train. Temperature measurements are important for correcting stack gas parameters to standard conditions. Precise temperature measurements are essential in order to obtain more accurate test results.

507.2.2.1 Temperature Reference and Thermocouples

A commercial mercury thermometer is sufficient for calibration purposes. Before sampling, the gauge should be calibrated at several temperatures spanning the expected stack temperature, using water bath immersion, boiling water, and hot mineral oil.

A thermocouple (or another temperature sensing gauge) should be installed on the sample probe assembly with sufficient clearance to not interfere with the pitot tube and nozzle operation. Thermocouple wires are purposefully thin in order to increase sensitivity. They must be thoroughly inspected routinely and any frayed or damaged wire should be replaced or repaired. Insulation must be complete, and the thermocouple junction should be either welded or silver-soldered. The temperature gauge must be calibrated prior to use, to read within +/- 1.5 percent at the stack temperature. After field use, the gauge must be checked at a temperature within 10 percent of the average stack gas temperature.

507.2.3 Pitot Tubes

The Type S Pitot tube construction details should be carefully checked before calibration. The value of the calibration factor (C_p) for a properly constructed Type S Pitot tube will be approximately 0.84 (may range from 0.79 to 0.87). The tube should be made of stainless steel, or quartz (for high temperature gas streams) with a tubing

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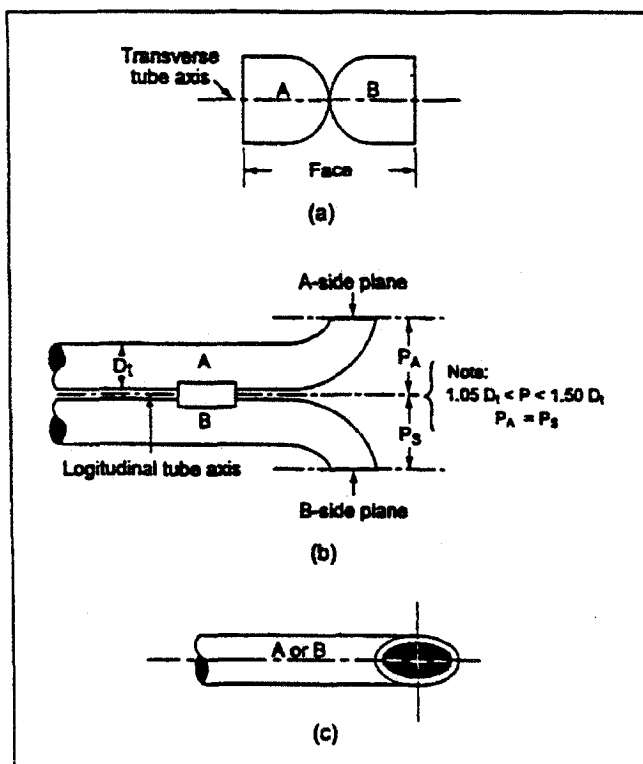


Figure 507.3 Properly Constructed Type S Pitot Tube

diameter between 0.48 and 0.95 cm. The distance from the base of each pitot tube leg to the plane of the orifice opening should be equal (See **Figure 507.3**). Pitot tube orifice openings should be properly aligned (parallel to the axis of the pitot tube and perpendicular to the stack gas flow). Misalignment of the openings can effect the pitot tube calibration coefficient and should be corrected before calibration or use.

Inspection of the pitot tube is the most detailed of the sampling train inspections. It consists of checking the alignment, placement on the probe, and calibration. The face openings of the Type S Pitot tube must be parallel to each other and to the axis of the pitot tube assembly and the pitot tube must be straight and undented.

The pitot tube must also be attached to the probe in such a way that the probe, nozzle, and thermocouple do not interfere with its operation. If a standard type pitot tube is

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being used it should be inspected for straightness, lack of dents (especially important), and general conditions and maintenance that would effect its operation.

Prior to calibrating the Type S pitot tube, make sure the duct gas flow system is at a steady rate and check to make sure that there is no cyclonic gas flow. Check the pressure differential gage for zeroing, level, fluid density, and volume. Leave the manometer connections set and switch lines at the pitot tubes. Make sure the pressure gage is in an area free of any vibrations. Calibrate the Type S pitot tube using the following procedure:

1. Leak test the pitot tube and tubing by sealing the pitot tube opening and then establishing a positive pressure greater than 3 in. at the opening. The manometer pressure should remain stable for at least 15 seconds. Repeat the procedure for the static pressure side of the pitot tube, using negative pressure. Perform this check on each pitot tube used in the calibration process.
2. Use the standard pitot tube and measure the gas velocity pressure at the center of the calibration duct. Also measure gas temperature. The sensing orifice must be parallel to the duct axis while perpendicular to the gas flow. The standard pitot tube entry port should be sealed around the tube. The Type S pitot tube port should be sealed.

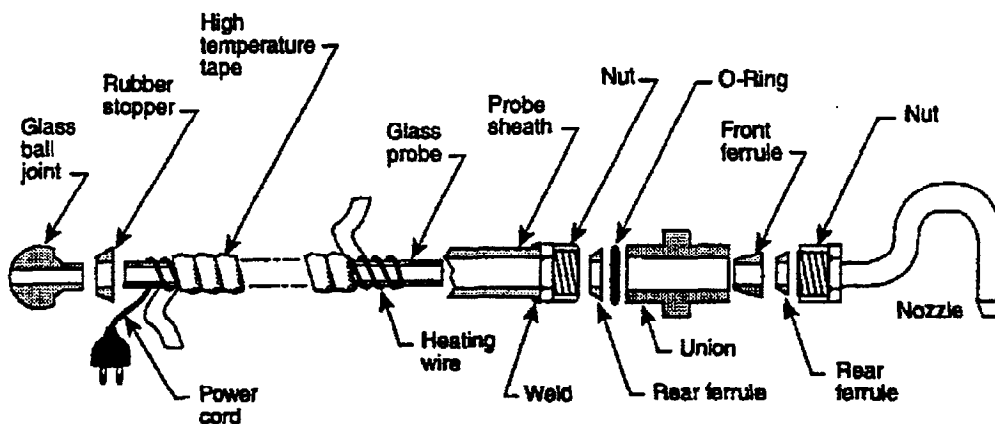


Figure 507.4 Probe Assembly

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3. Record all data and then disconnect the standard pitot tube from the differential pressure gage. Remove the tube from the port and seal the port.
4. Assemble the Type S pitot tube and accessories to minimize aerodynamic interferences.
5. Connect the Type S pitot tube to the differential pressure gage and insert the tube assembly into the duct. The gas velocity measurement for the Type S must be the same as from the standard tube, and the pitot tube leg must be properly aligned to the gas flow. Seal the Type S pitot tube and record all data.
6. Repeat the preceding steps until three readings have been made for leg A. Calibrate leg B using the same procedures. For each of the Δp readings, calculate the value of the Type S pitot tube coefficient as follows:

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{\Delta P_{std}}{\Delta p_s}}$$

Where:

$C_{p(s)}$	=	Type S pitot tube coefficient
$C_{p(std)}$	=	Standard pitot tube coefficient; use 0.99 if the coefficient is unknown.
Δp_{std}	=	Velocity head is measured by the standard pitot tube, inches in H_2O
Δp_s	=	Velocity head measured by the Type S pitot tube, cm (in.) in H_2O .

Calculate C_p (side A), the mean A side coefficient, and C_p (side B), the mean B side coefficient; calculate the difference between these two average values.

Calculate the deviation of each of the three A-side values of $C_p(s)$ from C_p (side A), and the deviation of each B-side value of $C_p(s)$ from C_p (side B) using the following equation:

$$\text{Deviation} = C_{p(s)} - C_p \text{ (A or B)}$$

Use the type S pitot tube only if the values from (side A) and (side B) are less than or equal to 0.01 and if the absolute value of the difference between C_p (A) and C_p (B) is 0.01 or less..

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507.2.4 Control Console

The control console is the center of the sampling system, and consists of the pump, dry gas meter, orifice meter, filter heater controls, manometers and system valving. The system must contain a leak free pump able to draw an isokinetic sample through the train and therefore capable of creating an absolute pressure greater than or equal to 3 in Hg.

The dry gas meter should be checked to make sure it is leak free and operating properly. The meter should be accurate and be calibrated before and after the source test. The meter dial face should measure 0.1 ft.³ of dry gas per revolution.

The differential pressure gauge recommended for Method 5 is an oil manometer, capable of measuring velocity pressure to within 1.3 mm water column. A Magnehelic gauge may be used if it is calibrated before a test and between each test series against an oil manometer. Electric manometers are also commonly used in source tests.

The meter console apparatus may be capable of monitoring and maintaining all equipment temperatures in addition to measuring stack gas temperature. The temperature at the dry gas meter should be checked to make sure it is operating properly. The meter should be calibrated before and after the source test. The dry gas meter should be checked to make sure it is leak free and operating properly. The meter should be calibrated before and after the source test. The temperature at the filter compartment must be measured to within 3°C.

The meter console must be calibrated and leak checked prior to operation. Meter console operating procedures are specific per manufacturer; however, a basic format can be followed.

When checking for leaks, the sample train is first assembled as intended for use in the test. Then, turn on the probe and filter heating systems and wait until operating temperatures are reached. Disconnect the umbilical cord vacuum line and turn on the meter console pump. This allows the pump to lubricate itself and to warm up. Leak-test the pitot tube lines during this warm up.

The pitot tube impact pressure leg is leak-tested by applying a positive pressure. Blow into the impact opening until greater or equal than 7.6 cm of water indicated by the differential pressure gauge. Seal the impact opening. The pressure should be stable for at least 15 seconds. The static pressure leg of the pitot tube is leak-checked using

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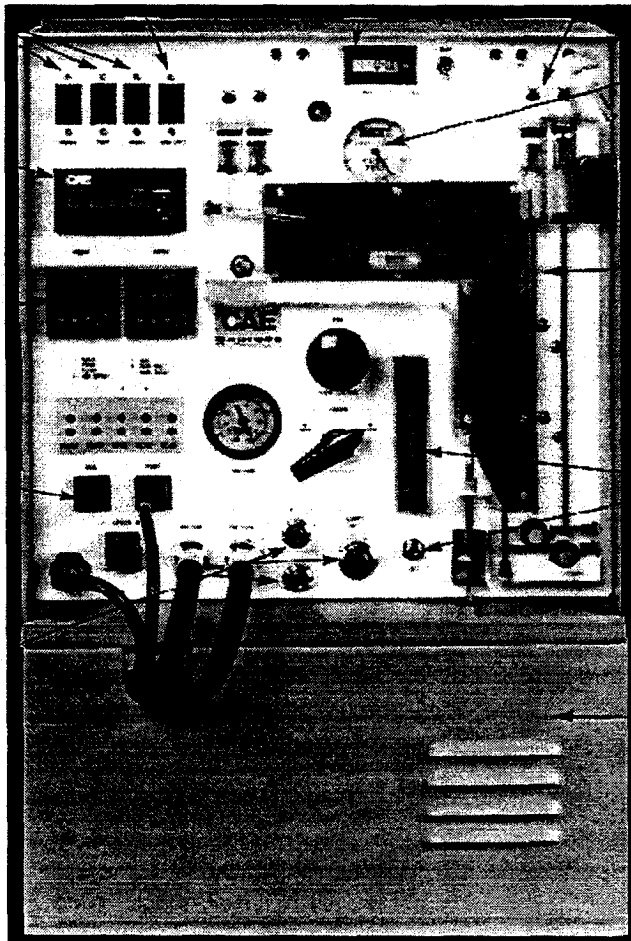


Figure 507.5 Control Console

the same procedure with negative pressure. The leak-check procedure should be performed on each pitot tube used.

507.2.5 The Sample Case

The sample case is used for support, protection and environmental control of the glassware in the sampling train. It consists of an insulated heated filter compartment (hot side sampling case) and an insulated impinger case (cold side sampling case). It should be lightweight, easily adaptable, solidly constructed and have well-insulated electrical connections. It must be checked thoroughly for any necessary repairs. All handles, clamps, brackets and electrical connections must be inspected for damage.

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Insulation in both the hot and cold areas must be in good repair. The sample case must not leak water from the melting ice into the filter heating compartment area. A protective foam padding and a good drainage system must be present in the impinger section, and the drain plug must be clean.

507.2.6 Hot Side Sampling Case

The hot side of the sampling train usually includes a filter for particulate collection, which is heated to prevent the condensation of water. Any condensate and condensable particulate is collected on the impingers. For a Method 5 test, the filter compartment should be heated to 120° C +/- 14° C. The observer should check that the compartment has reached operating temperature before the pre-leak check has been performed and before the sampling begins.

The filter used is made of glass or quartz and contained in a glass or stainless steel filter holder, supported by a stainless steel or glass frit and sealed with a rubber gasket.

The observer should check to make sure that the filter assembly is clean and properly assembled. After sampling, the observer should then observe the disassembly and recovery of the filter to check for deposits and that no particulate has migrated beyond the gasket.

Note: When using the EPA Method 5, particulate matter used for calculations is that collected only on the filter and recovered from the filter holder, probe, and connecting glassware in front of the filter. In using ARB Method 5, the particulate calculation also includes the condensable particulate collected in the impingers, and the particulate recovered from the glassware in the back of the filter.

507.2.7 Cold Side Sampling Case

A cold side refers to the side of the sampling train that includes impingers immersed into an ice bath to condense and measure any moisture content (EPA and ARB Method 4). The source tester should check that the cold side of the sampling train is properly set-up and leak checked. Impingers used may be mini or standard size, and the tips can be standards, modified, or glass frits depending on the method specification. The last impinger should be fitted with a temperature measuring device at the exit

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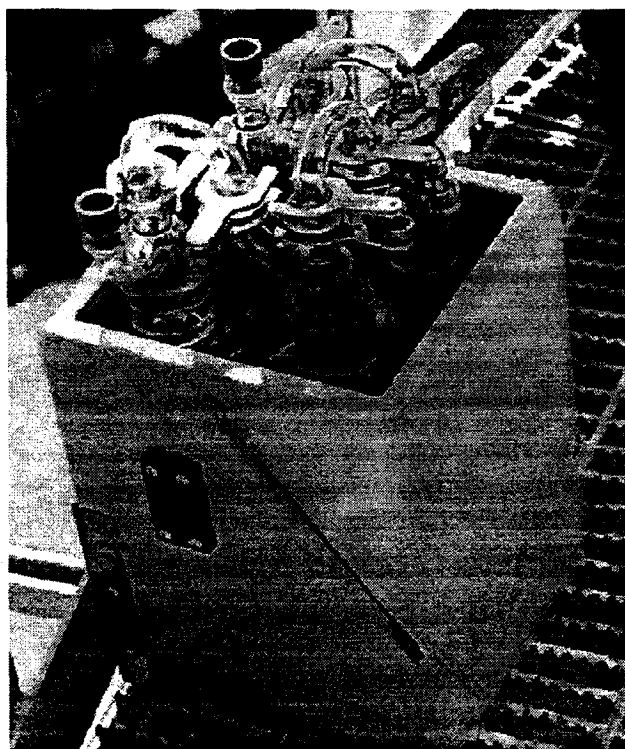


Figure 507.6 Cold Side Sampling Impingers

to measure the outlet gas temperature. The test team should be recording temperatures and adding ice or salt as needed to maintain the correct temperature (20° C for Method 5).

507.2.8 Umbilical Cord

The umbilical cord houses the sample gas line, the pitot tube tubing, the electrical heating control wiring, and 110V electrical supply and carries them in a single casing from the sample platform to the control box, usually at ground level. The lines should be color coded for easy hookup. For most testing a fifty foot cord is sufficient with one hundred feet the maximum recommended length. However, length is limited by the ability of the pump to overcome the friction loss of the total system while still achieving the required flow rate.

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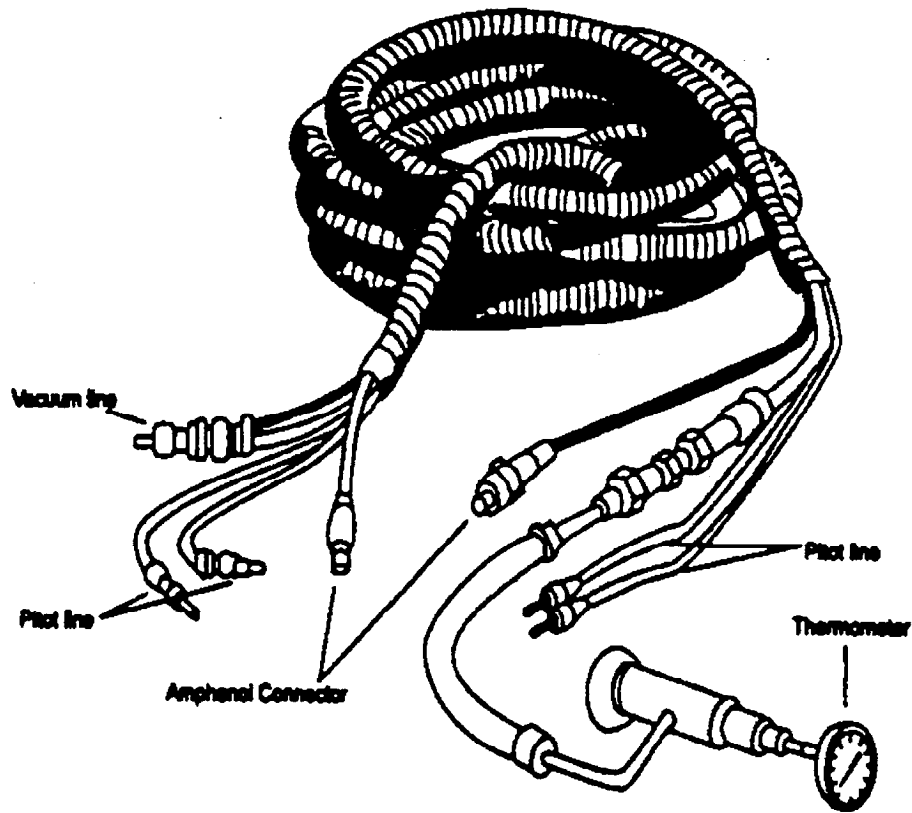


Figure 507.7 Umbilical Cord

507.2.9 Metering Orifice

A calibrated metering orifice is located on the outlet of the dry gas meter. An inclined manometer is connected across the orifice which is used to measure the sampling rate. The manometer reading is ΔH on the nomograph and is the value entered in the data recording sheets. The meter must be calibrated at several flow rates corresponding to pressure differentials (ΔH of 0.1, 0.5, 1.0, and 1.5 inches of water). **Figure 507.8** shows the Type S Pitot Tube and the orifice meter.

508 THE SOURCE TEST

Performing a stationary source emissions test is really the execution of an original scientific experiment, which when done properly will provide accurate data on source emission parameters. The experiment requires that certain objectives be decided

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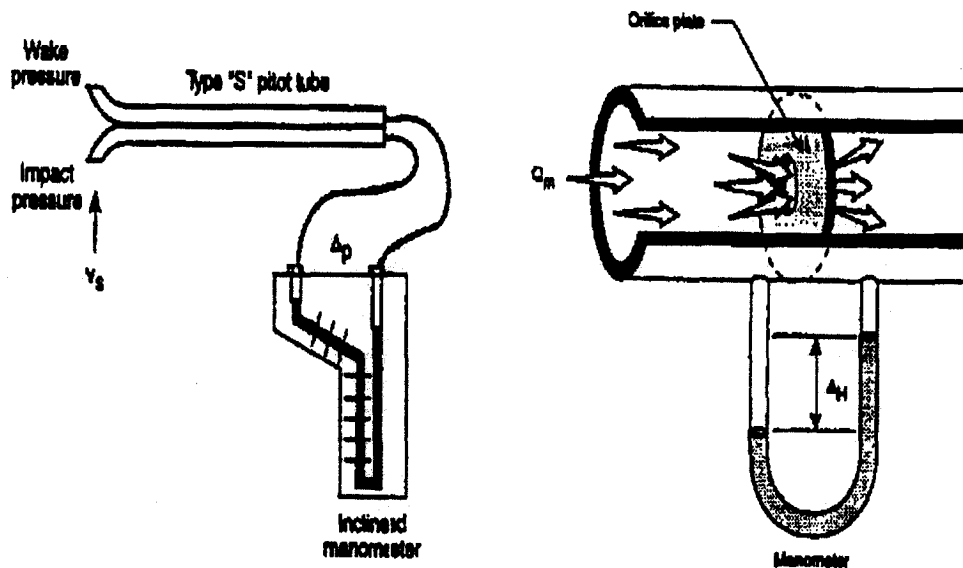


Figure 507.8 Type S Pitot Tube and Orifice Meter

before starting and that the procedures and equipment are designed to aid in reaching those objectives. Included in the objectives should be the quantitative or qualitative analysis of the source sample, which is an integral part of the source test. The results of the test should be evaluated to determine whether or not the objectives have been met.

508.1 METHOD 5 OVERVIEW

In the test for particulate sampling, the velocity at the intake nozzle must be equal to the velocity of the gas in the stack. The sampling must be performed at an isokinetic ratio of between 90% to 110 % in order for the test to be acceptable.

For the velocity in the sampling nozzle to be constantly equal to the velocity of the stack gas, the stack gas velocity and its temperature must be constantly measured and the sampling rate must be adjusted accordingly. The equipment in the sampling train is designed so that these adjustments can be made quickly.

In order to obtain an average concentration of the stack gas, the stack must be traversed by the sampling probe. Samples are drawn from the stack at the traverse points chosen using Method 1.

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508.2 PARTICULATE CONCENTRATION DETERMINATION AND EMISSION RATES

In a source test, particulate matter concentration is measured by isokinetically collecting a volume of the stack gas and catching the particulate in the filter, the probe, the connecting tubing, and in the impingers, and then by dividing the weight of the particulate catch by the volume of gas.

Particulate matter concentration alone, however, will not give the total emission rate. Emission rates are calculated by including the particulate concentration, the pollutant mass rate, the process rate and the flow rates of F factors based on the combustion to determine specific types of fuel. The following equation is used to determine the total emission rate:

$$F = \frac{\text{pmr}_s}{Q_H} = \frac{C_s Q_s}{Q_H}$$

Where:

- F factors = factors to determine the volume of stack gas resulting from the combustion of fuel
- pmr_s = pollutant mass rate from the stack
- Q_s = stack flow
- Q_H = heat rate input
- C_s = concentration of the pollutant from the stack

Always check the source permit provisions and applicable regulations to determine to appropriate parameters to measure.

508.3 SAMPLING TRAIN

As a review, the sampling train consists of a sampling nozzle, a heated sampling probe, a filter, four impingers, a gas pump, a dry gas meter, and a metering orifice. The Type S pitot tube is attached to the length of the sampling probe. A manometer is connected across the metering orifice to indicate flow rate. A bypass around the pump controls the flow of gas through the train by recirculating part of the capacity of the pump. Therefore, opening the valve in the bypass will decrease the flow of gas through the sampling train, and maximum flow through the train occurs when the bypass valve is closed.

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508.4 ARRIVING AT THE SITE

Establishing communication among all parties involved in the test program is essential when performing a source test. The source test team should notify the plant and regulatory agency upon their arrival. Information regarding the plant operations and sampling plan should be reviewed and understood by all parties involved in the testing.

508.4.1 Review Safety Procedures

Safety is a primary concern to all involved when carrying out a source test. Sampling is performed at a variety of industrial sites and under different circumstances. The test team must be aware of safe operating methods so that the team can be prepared to act and modify safety practices when necessary. Safety is an issue that each team member must be aware of. Each team member, including the observer must be responsible for his or her own safety, as well as the other team members. Also, an important factor in any safety program is using common sense.

508.4.2 Accident Prevention

If a good safety program is established, accidents can be prevented. There are a number of common causes of accidents:

- Failure of supervisory personnel to give adequate instructions, or poor job site inspection.
- Failure of the person in charge to properly plan or conduct the activity. Prior planning is the key to good safety.
- Improper design, construction, or layout of project.
- Lack of protective devices or improper tools and equipment.
- Neglect or improper use of personnel following rules or instructions.
- Faulty, improperly maintained devices.
- Failure on the part of any personnel to follow rules or instructions.
- Personnel in poor physical condition or with a poor mental attitude.
- Personnel without adequate knowledge or training for performing job tasks.
- Unpredictable agents outside the organization, who may not understand the rules.

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Weather can also be an important factor that needs to be considered in source test plans. It can affect the safety of personnel doing work on a stack, and can be a potential electrical hazard.

508.5 SETUP EQUIPMENT

All preliminary equipment preparation, such as assembly, inspection, and calibration should have been done prior to movement to the field setting. Therefore, the entire sampling assembly should be set-up and ready to use for the test. Any additional preparations and spare parts should be accounted for and packed.

The meter console must be calibrated and leak checked prior to operation. Meter console operating procedures are specific per manufacturer, however, a basic format can be followed.

Assemble the equipment in sequence in the sampling train for the Method 5 test. The train is usually set up in the following order:

1. Sampling nozzle (size determined prior to test day)
2. Stainless steel probe
3. Type S pitot tube
4. Filter, glass filter holder, filter paper - Check filters visually against light for irregularities and flaws or pinhole leaks. Label filters of the proper diameter on the back side near the edge using markers. As an alternative, label the shipping containers (glass or plastic petri dishes) and keep the filters in these containers at all times except during sampling and weighing. Desiccate the filters at $20^{\circ} \pm 5.6^{\circ} \text{ C}$ ($68^{\circ} \pm 10^{\circ} \text{ F}$) and ambient pressure for at least 24 hours and weigh at intervals of at least 6 hours to a constant weight, i.e., 0.5 mg change from previous weighing; record results to the nearest 0.1 mg. During each weighing the filter must not be exposed to the laboratory atmosphere for a period greater than 2 minutes and a relative humidity above 50 percent. Alternatively, (unless otherwise specified by the Executive Officer), the filters may be oven dried at 105° C (220° F) for 2 to 3 hours, desiccated for 2 hours, and weighed. Procedures other than those described, which account for relative humidity effects, may be used, subject to the approval of the Executive Officer.
5. Four Impingers - Weigh several 200 to 300 g portions of silica gel in airtight containers to the nearest 0.5 g. Record the total weight of the silica gel

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plus container, on each container. As an alternative, the silica gel need not be preweighed, but may be weighed directly in its impinger or sampling holder just prior to train assembly. The first impinger catches any material that would clog the nozzle of the second impinger. The second impinger catches fine particulate matter. The third and fourth collects any remaining water or particulate matter.

6. Umbilical cord

7. Control console which houses the:

Pump

Dry gas meter

Vacuum gauge

Metering Orifice

Pitot tube and metering orifice manometers and

Heater controls

508.5.1 STACK, PLATFORM AND EQUIPMENT

Examine the stack prior to the beginning of the test. The source test team should climb the stack and ensure that all equipment is present on the stack platform and in good operating condition.

- Sample port caps (should be removed)
- Probe Monorails
- Power cables
- Umbilicals/Heated Lines
- Continuous Emissions Monitoring (Method 100) probe
- Control Consoles - The meter console must be calibrated and leak checked prior to operation. Meter console operating procedures are specific per manufacturer, however, a basic format can be followed.
- Ice/Chests
- Shelter
- Tables/Chairs

508.5.2 Calibration Gas Van

A large van equipped with a gas tank storage area is used at the source test. The calibration gas tanks must not be out-of-date. The following items must be checked prior to sampling:

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- Power to the van
- Sample Conditioner
- Instrument Calibrations
- Sampling System Calibrations

508.6 PRELIMINARY MEASUREMENTS OF GAS VELOCITY, MOLECULAR WEIGHT AND MOISTURE

U.S. EPA and ARB Methods 1 through 4 are used to gather the preliminary values for Method 5 sampling. Before the source test can begin, measurements must be made to establish the desired isokinetic sampling rate. Several values need to be determined such as the probe nozzle size, the $\Delta H/\Delta p$ ratio (K factor) needed for isokinetic sampling, and the gas sample volume. **Figure 508.1** shows the inputs of Methods 1 through 4 to calculate the values for Method 5 sampling, whereas **Figure 508.2** shows the inputs of Method 1 through 4 during the Method 5 test run.

508.6.1 Mark Pitot Tube/Thermocouple Assembly, using Method 1.

Method 1 is the first step towards collection of a representative sample for measuring particulate concentration and mass emissions rate from a stack. Select the sampling site and the minimum number of sampling points according to Method 1 or as specified by the Executive Officer. Add the port nipple length to the value for each traverse point.

508.6.2 Perform Velocity Traverse using Method 2.

Determine the stack pressure, temperature, average velocity and volumetric flow rate of the stack gas using Method 2. There are two instances when Method 2 will be used:

1. Prior to a particulate stack test series, to determine the size of the nozzle and length of the sampling run, and
2. During each stack test run, to ensure that the particulate sample is extracted from the stack at isokinetic conditions.

Perform according to Method 2 or as specified by the Executive Officer.

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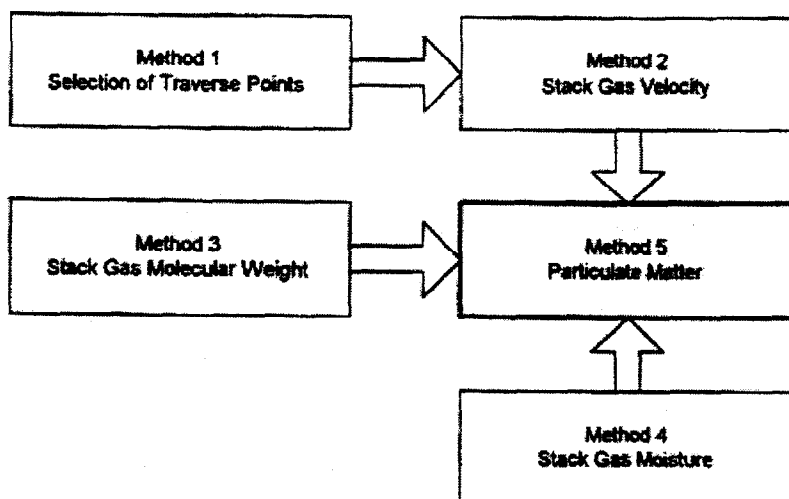


Figure 508.1 Input of Methods 1 through 4 to Method 5 Calculations

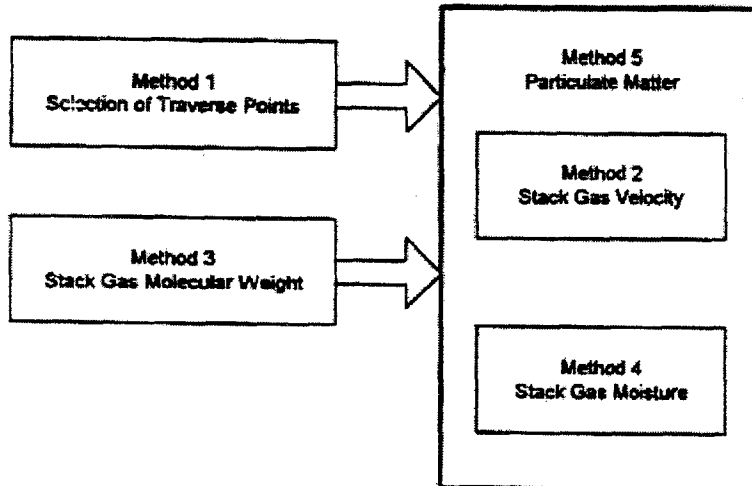


Figure 508.2 Input of Methods 1 through 4 during Method 5 Test Run

508.6.3 Perform a Stack Gas Analysis for the Determination of Molecular Weight using Method 3.

Method 3 is used to measure the percent concentrations of carbon dioxide (CO_2), oxygen (O_2), and carbon monoxide (CO) if greater than 0.2%. Nitrogen is calculated by the difference. From this data, the stack gas dry molecular weight, or density,

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is calculated, and is used in the equation for stack gas velocity. Then, from the gas composition data, the amount of excess air for combustion sources can be calculated.

There are three different options for determining dry molecular weight:

1. Sample and analyze,
2. Calculate the O_2 and CO_2 stoichiometrically for combustion sources, or
3. For fossil fuel burning, assign a value of 30.0 for dry molecular weight.

The stack gas sample can be collected using one of following options:

1. Grab sampling from a single traverse point a portion of the stack gas using one-way squeeze bulb and then loading directly into the analyzer.
2. Integrate sampling from a single traverse point into a flexible leak-free bag. This technique recommends collection of at least 30-liters, however smaller volumes may be collected if desired. A constant sampling rate must be used.
3. Integrated sampling from multiple points into a flexible leak-free bag. This technique is used when conducting a Method 5 particulate traverse and using the Orsat gas collection line built into the probe assembly.

Perform according to Method 3 or as specified by the Executive Officer.

508.6.4 Determination for Moisture Content using Method 4.

There are two separate procedures for determining moisture content in stack gases:

1. The Reference Method for accurate measurements of moisture as needed to calculate emission data, and
2. The approximation method, which measures a good estimate of percent moisture to aid in setting isokinetic sampling rates prior to a pollutant emission run.

Alternative ways for approximating moisture content are also acceptable, such as:

1. Wet bulb/dry bulb techniques (applicable to gas streams less than $100^\circ C$),
2. Stoichiometric calculations (applicable to combustion sources),
3. Condensation techniques,
4. Drying tubes, and
5. Previous experience testing at a stack.

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Determine the moisture content using the Approximation method outlined in Method 4, or its alternatives for the purpose of making isokinetic sampling rate settings, or as specified by the Executive Officer.

508.7 CALCULATE NOZZLE SIZE

There are many ways to calculate the probe nozzle size and K-factor needed for the isokinetic sampling rate. They include:

1. Using a specially designed stack testing slide rule nomograph,
2. Using a pre-programmed hand-held calculator,
3. Calculating by hand or on a worksheet.
4. Using a personal or laptop computer equipped with specialized spread sheets for data collection and reduction.

The following preliminary information is required to select the nozzle size and to calculate the K-factor:

1. Average stack gas velocity head (Δp_{avg}). The data from a previous test can be used, or use the measurement before the sample run.
2. Stack gas moisture fraction (B_{ws}) or percent ($\%H_2O$). This data also can be used from a preliminary run, previous test, or calculated using Method 4.
3. Stack gas dry molecular weight (M_d). This may be determined from a preliminary run, previous test or estimated using Method 3.
4. Stack gas pressure (P_s). This is measured before the sample run, or if the static pressure of the stack is very low (the sample ports are close to the stack exit) the barometric pressure is used.

508.8 ASSEMBLE SAMPLING TRAIN

Please refer to **Figure 508.3**, Method 5 Sampling Train Schematic and **Figure 508.4**, Assembled Sampling Train.

1. Use heat-resistant tape or permanent markers to mark the probe assembly to denote the proper distance into the stack or duct for each sampling point.
2. Insert the probe nozzle into the probe sheath and tighten the fitting. Do not overtighten. Keep the nozzle tip and the ball joint on the glass probe liner covered until the assembly of the train is complete and sampling is

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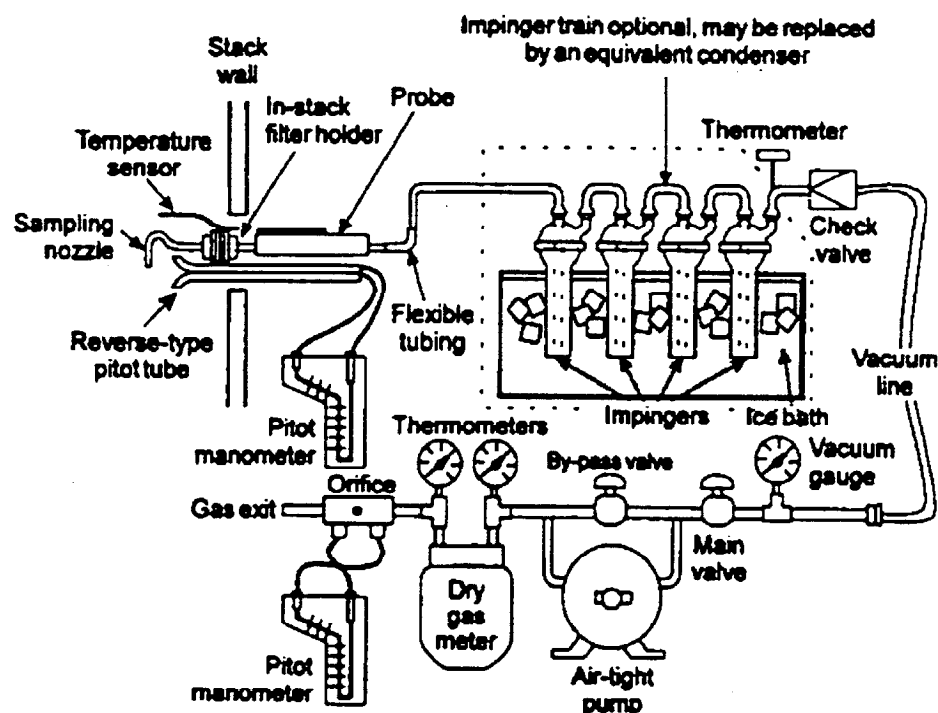


Figure 508.3 Method 5 Sampling Train Schematic

about to start. Tighten the clamp to secure to probe assembly to the sample case.

3. Place 4 clean impingers into the aluminum impinger case.
4. Add 100 ml of deionized-distilled water to each of the first two impingers. The third and fourth impingers remain dry.
5. Interconnect impingers with vinyl tubing cut to the shortest length possible without causing tubes to collapse under vacuum.
6. Attach length of impinger-to-probe tubing to first impinger.
7. Install umbilical connector on downstream stub of fourth impinger and connect to umbilical line.
8. Close impinger case drain valve, and add water to depth of 2 to 4 inches.
9. Assemble pre-weighed fiberglass filter disc in filter holder.
10. Using a felt-tip marking pen, identify each impinger and filter holder with test run number. Record filter number on the field data sheet.
11. Attach the filter holder in the heater box to the probe liner ball joint and to the "L" adapter using ball joint clamps.

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12. Connect the umbilical cable electrical and pitot tube line connections to the assembled sampling train and the meter console. Then, if necessary, connect the Orsat line. Attain grounding cable from the probe to nearest suitable ground.
13. Place the assembled sampling train close to the first sampling port, and let rest on the monorail or other support.
14. Turn on console switches for filter heater box and probe heater.
15. Pre-heat filter and probe for at least 15 to 25 minutes before starting the test, and make checks and adjustments to ensure the desired temperature. Check all thermocouple connections by dialing through each selection and noting heated or ambient temperatures. Add crushed ice and a little water around the impingers in the impinger case.

508.9 CONDUCT LEAK TEST

To leak check the sampling train, first turn on the probe and filter heating systems and wait until the operating temperatures are reached. Leak test the assembled train by plugging the nozzle and pulling 15 in. Hg vacuum. A leakage rate of 0.02 cfm is acceptable. Turn off main console value first then shut off pump.

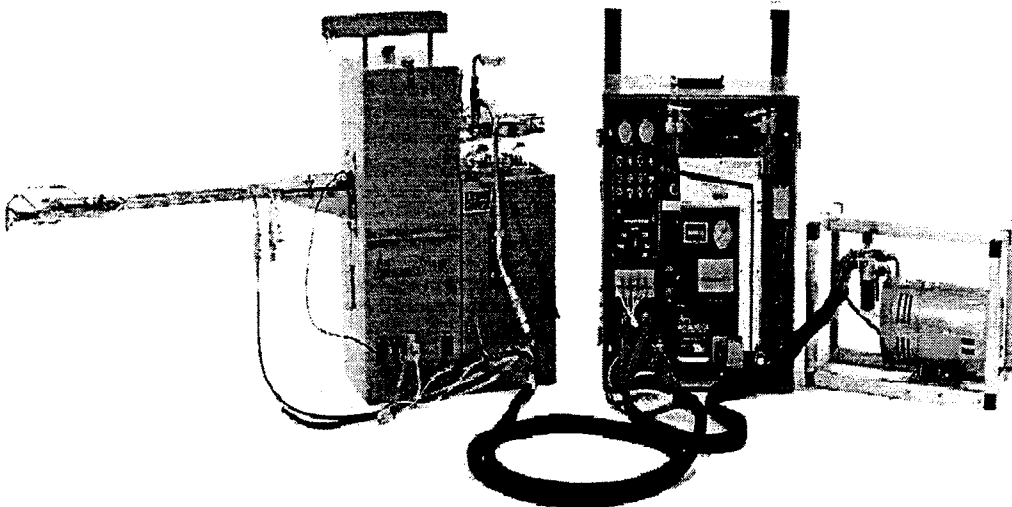


Figure 508.4 Assembled Sampling Train

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The pitot tube impact pressure leg is leak-tested by applying a positive pressure. Blow into the impact opening until greater or equal than 7.6 cm of water indicated by the differential pressure gauge. Seal the impact opening. The pressure should be stable for at least 15 seconds. The static pressure leg of the pitot tube is leak-tested in a similar way by drawing a negative pressure less than or equal to -7.6 cm of water. Correct any leaks found.

508.10 PREPARE DATA SHEETS

All data sheets must be made available prior to the start of the test and filled out properly. Copies of the following data sheets are contained in Appendix C of this manual.

1. Method 5 Run Sheet
2. Method 100-CEM Charts/Data Sheets
3. Process Data Sheets

508.11 START TEST RUN

Follow the procedure outlined below to conduct the sampling run.

508.11.1 Inform Plant Contact

It is important to alert the plant manager/contact that the test run is beginning. This will remind him to ensure that the process remains at a constant rate, if possible, during the test. It is also good for safety reasons for the plant staff and the source test team.

508.11.2 Check Process Data

Prior to the start of the test, make sure that the process is running at a normal representative level of plant operation.

508.11.3 Sampling

1. Open and clean the portholes of dust and debris.
2. Level and zero the Δp and ΔH monometers.
3. Record data on a field data sheet. Record the initial dry gas meter (DGM) reading.
4. Remove the nozzle cap, verify that the filter and probe heating systems are up to temperature, and check pitot tube, temperature gauge, and

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probe alignments and clearances.

5. Close the coarse valve and fully open the fine increase valve. Position the nozzle at the first traverse point. Record the clock time, read Δp on the monometer, and determine ΔH from the nomograph. Immediately start the pump, and adjust the flow to set the ΔH , first by adjusting the course valve and then the fine increase valve.
6. When the probe is in position, block off the openings around the probe and porthole using duct tape, rags, gloves or towels (or flameproof materials for hot stacks).
7. Record the ΔH , pump vacuum and temperatures for stack gas, DGM, filter box, probe, and impinger exit. Record the ID numbers for DGM, thermocouples, pitot tube, and sample box.
8. If running the Method 3 gas bag collection at the same time, turn on the Orsat pump. Turn Orsat pump off during port changes.
9. Traverse the stack cross-section for the same time period at each point without turning off the pump except when changing ports.

It is important to not bump the probe nozzle into the stack walls.

Remember to:

- a. Keep the pemperature around the filter holder at the proper level, and
 - b. Monitor the Δp during each point, and if the Δp changes by more than 20%, record another set of readings.
 - c. Check the level and zero of the monitors periodically, and re-adjust if required.
 - d. Record DGM readings at the beginning and end of each sampling time increment, before and after each leak-check, and when sampling is halted.
 - e. Record all the other readings (ΔH , temperatures, vacuum) at least once at each sampling point during each time increment, trying to maintain the $\Delta H/\Delta p$ isokinetic ratio.
 - f.. Add more ice and, if necessary, salt to maintain a temperature of less than 20°C or 68°F at the silica gel impinger exit.
10. When the sample run is finished, turn off the course valve, remove the probe and nozzle from the stack, turn off the pump and heaters, and record the final DGM reading.
 11. **Repeat for Three Sample Runs**

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Mandatory: Leak-check the sampling train at the maximum vacuum achieved during the sample run. Record the leak-check results on the field data sheet.

Mandatory: Leak-check the pitot tube lines. Record on the field data sheet.

508.11.4 POST TEST EQUIPMENT PROCEDURES

Upon conclusion of all three sampling runs, the following steps must be taken with the equipment.

1. Allow the probe to cool. Then, wipe off all external particulate matter near the tip of the probe nozzle, and cap the nozzle to prevent contamination or loss of sample.
2. Prior to moving the sampling train to the clean-up site, disconnect the probe from the bypass inlet and cover both ends. Do not lose any condensate that might be present. Disconnect the filter holder from the "L" adapter and cap off the filter holder.
3. Disconnect the umbilical cord from the sample box and cover the last impinger outlet and first impinger inlet. Disconnect the cold box from the hot box. At the point, the probe/nozzle assembly, filter holder, and impinger case are ready for sample recovery.
4. Transfer the probe and filter-impinger assembly to a clean-up area that is clean and protected from the wind and weather.

508.12 MONITOR PROCESS DATA

1. Collect Control Room Data
2. Collect Other Process Data, as Necessary
3. Sample Process Materials, if Necessary

508.13 METHOD 100 - CEM OPERATION

1. Monitor Stack Gas Oxygen and Carbon Dioxide Concentrations
2. Monitor Gaseous Pollutants
3. Conclude Test
4. Record Clock Time and Elapsed Time
5. Record Final Dry Gas Meter Reading

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6. Conduct Final Leak Test at Highest Vacuum Observed
7. Perform Post-Test Leak Check

509 SAMPLE RECOVERY

1. Remove the nozzle and rinse the inside surfaces with deionized-distilled water and acetone or other suitable solvent. Use a small bristle brush or rubber policeman to clean any particles remaining after rinse. Collect rinsings in the sample jar.
2. Cleaning the probe is a two-person job. One person squeezes the rinse bottle over the probe and the other holds the sample jar to catch the rinse liquid.
3. Rinse the probe with deionized-distilled water or acetone to remove large particles. Slowly rotate probe during rinse.
4. Run a gun bore brush through the probe. Then withdraw the brush and rinse both the brush and the probe again.
5. Collect all the rinsings in a sample jar and label the jar with the identification and date.

509.1 Recovery of Sample from Filter Assembly

1. Remove the retaining nuts and separate the two filter halves with the filter disk side up.
2. Carefully remove the filter disk from the supporting glass frit, and place in its plastic petri dish. Cover the dish and seal with masking tape. It is important to store the petri dishes with the particulate side of the filter disk up.
3. Scrape residual filter material from silicone seal and add to petri dish.
4. Rinse the upstream half of the filter and add rinse water to the sample jar containing the probe rinse. Use a rubber Scraper to remove material not removed by rinsing.
5. Rinse to downstream half of the filter assembly and support frit and add to the impinger rinse.

509.2 Recovery of Sample from Impingers and Connecting Tubing

1. Remove the vinyl tubing from the impinger stubs by cutting tubing length wise over the stubs.

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2. Rinse each tube length with deionized-distilled water and collect the rinse water in a sample jar.
3. Remove the impingers from the impinger case and place in rack.
4. Starting with the No. 1 impinger, wipe the dust from its stopper to prevent external dust from falling into the impinger flask during the removal of the stopper.
5. Withdraw the stopper carefully from the flask.
6. Rinse all surfaces of stopper exposed to gas streams with deionized distilled water and collect rinsings in sample jar.
7. Wipe the silicone grease from the flask ground joint using a kimwipe moistened with a acetone or freon precision cleaning agent.
8. Pour the contents of the No. 1 flask into a graduated cylinder.
9. Rinse flask with deionized-distilled water, and with acetone to dissolve oil or resins and collect rinsings in sample jar.
10. Repeat above step on the remaining impingers.
11. Rinse each length of connecting tubing with deionized-distilled water only.
12. Record net amount of condensed water collected as measured in graduated cylinder, and add to sample jar.
13. Label each sample jar with test identification number and date.
14. Deliver all sample jars and filters to the laboratory.

510 CALCULATIONS

At the end of each sampling run, it is wise to calculate the stack gas moisture for the next sampling run, as well as the average isokinetic rate.

510.1 Calculation of Stack Gas Moisture

In order to calculate the stack gas moisture content (B_{ws}), the following equations are used to compute the sample gas volume ($V_{m(std)}$) and gas moisture volume ($V_{wc(std)}$):

$$V_{m(std)} = K_3 Y (Vm(P_{bar} + \Delta H/13.6))/T_m$$

Where ΔH = Average orifice tube pressure during sampling, mm H₂O (in. H₂O)

V = Dry gas volume measured by dry gas meter, dcm (dcf)

T_m = Absolute temperature at dry gas meter, °K(°R)

Y = Dry gas meter calibration factor

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$$K_3 = 0.3858 \text{ } ^\circ\text{K/mm Hg (metric units)}$$

$$= 17.64 \text{ } ^\circ\text{R/in. Hg (English units)}$$

$$V_{wc(std)} = K_2(W_f - W_i)$$

Where W_f = Final weight of water collected, g
 W_i = Initial weight of water collected, g
 K_2 = 0.001335 m³/g (metric units)
 = 0.04715 ft³/g (English units; and

$$B_{ws} = V_{wc(std)} / V_{m(std)} + V_{wc(std)}$$

Where B_{ws} = Proportion of water vapor, by volume, in the gas stream.

Then, calculate the average stack gas velocity. The equation used for average stack velocity in the stack or duct is:

$$V_s = K_p C_p (\Delta p^{1/2})_{avg} (T_{s(avg)} / P_s M_s)^{1/2}$$

Where V_s = Average stack gas velocity, m/sec (ft/sec)
 C_p = Pitot tube coefficient, dimensionless
 $(\Delta p^{1/2})_{avg}$ = Average of the square roots of each stack gas velocity head
 T_s = Absolute average stack gas temperature, °K (°R)
 P_s = Absolute stack gas pressure, mm Hg (in. Hg)
 = $P_{bar} + P_g / 13.6$
 P_g = Stack static pressure, mm H₂O (in. H₂O)
 M_s = Molecular weight of stack on wet basis, g/g-mole (lb/lb-system)
 = $M_d (1 - B_{ws}) + 18.0 B_{ws}$
 K_p = Constant, 34.97 for metric system (85.49 for English system)

510.2 Calculation of Percent Isokinetic

Calculate percent isokinetic to determine whether the run was valid or another test run should be made. If there was difficulty in maintaining isokinetic rates due to source

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conditions, consult with the Executive Officer for possible variance on the isokinetic rates.

The average percent isokinetic sampling rate is calculated as:

$$\%I = K_4 T_s V_{m(std)} / P_s V_s A_n O (1 - B_{ws})$$

Where: A_n = Cross-sectional area of the nozzle, m² (ft²)
 O = Sampling time, minutes
 K_4 = 4.3200 (metric)
 = 0.09450 (English units)

For a quick review, all the necessary source test calculations are listed in Appendix E, Source Sampling Calculations, of this manual.

511 REPORT WRITING

Reports produced from source test data are records of the procedure and the test results. A source test report should cover all aspects of the test, from the objectives, test procedures and equipment, to the test results. A conclusion should be drawn based upon the test results, and stated in the report.

The report should be clear, accurate, and cover all areas of the test so that a quality control check could be performed based upon the report content. The source test report may end up as evidence in a case, and so will become legal documentation of the events and results of the test. It is very important to document the entire source test, to include all intermediate test values used in calculating test results. A report should allow you all the information necessary to recalculate the source test results, should you need to prove any part of the test in court.

511.1 The Test Report

The final test report should be a professionally written and presented document. It should have a title page which includes the tested facility name address and date, state the name of the organization performing the source test, and the report author. It should include a signature page containing signatures of all the personnel involved in the source test. Signatures can include those of the laboratory personnel, all test participants, supervisors, and report reviewer. The report may include a report

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number for the source testers reference. The report may include a table of contents which will help organize and ease the reading of the report.

511.2 Introduction

The report begins with an introduction which should state the test purpose. It includes a description of the source process and control system, and the sampling methods used. It covers facts such as test date, location and all industry, regulatory and test personnel involved with the test.

511.3 Test Results Summary

The next section of the report is the test results, mainly because this is the most important part of the report. The test results summary should be presented as a clear statement covering the test methods used and the results. All test methods used and referenced to either state, federal, or local government is included in the summary, as well as any test alterations and approvals. All emission standards and emissions rates are included with the units in appropriate English and metric. Any other comments are included such as process continuity and rates. The summary then follows with the test result conclusion which covers the entire test and results.

512 QUALITY ASSURANCE

Using quality assurance techniques in source testing is primary to obtaining test data that is accurate, precise and complete. By understanding and applying the different parts that make up quality assurance; error analysis, the observers role and calibration, good test results can be reported.

512.1 Error Analysis

The industrial environments in which source testing is conducted are not generally conducive to performing sensitive and accurate tests. In addition, it is not always possible for facility managers to maintain conditions suitable for testing. These conditions can easily lead to errors in test results. Appendix D of this manual contains error percentage charts for source emission testing.

Most stationary source tests results contain errors of some sort. An important part of the observer's role is to detect errors when they occur, to determine their impact on the test, and to take the best corrective action to expedite a successful and more

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accurate source test. An observer should evaluate the impact any error will have on the validity of the testing. If significant, the problem must be corrected before continuing and any test results containing the error must be voided. The analysis of the significance the error has on the test is one of the most difficult parts of the observer's duties. The observer needs to know some basic ideas to base his judgment of the significance of errors. They are:

- What the specific data is to be used for,
- The direction and magnitude of any biases, and
- What level of bias is acceptable.

512.1.1 Error Definitions

Error - The word "error" has two different meanings with regard to source testing. It may be used as the difference between a measured value and the "true" value. Error can also be defined as the estimated uncertainty in an experiment and is expressed in terms of standard deviation, average deviation, precision index, or probable error.

Discrepancy - Refers to the difference between two measured values of a quantity, such as different values found in a textbook of an actual experiment. The word "error" is often used inappropriately when referred to such differences.

Random Errors - Sometimes called experimental or accidental errors. When a given measurement is repeated, the resulting values do not always exactly agree and also may differ from the "true" values. The resulting errors from these causes are called random errors.

Systematic Errors - If all individual errors are in error by the same amount, then the errors are called systematic.

Determinate and Indeterminate Errors - These errors are evaluated by some kind of theoretical or experimental procedure. Those that are not are "indeterminate".

Corrections - Random errors and determinate systematic errors may be removed by applying appropriate corrections.

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512.1.2 Classification of Errors

Systematic errors are:

1. Errors in instrument calibration,
2. Personal errors caused by the habits of individual observers,
3. Experimental conditions such as pressure or temperature which are different than those at the time of calibration,
4. Imperfections in source testers techniques.

Random errors are:

1. Errors in judgement,
2. Fluctuating conditions,
3. Small disturbances such as those of mechanical vibrations,
4. Differences in the definitions of measurements.

Illegitimate errors are:

1. Blunders caused by outright mistakes in reading instruments, adjusting experiment conditions, or performing calculations,
2. Errors of computation such as calculator or computer error,
3. Chaotic errors such as reasonably large disturbances.

512.1.3 Precision and Accuracy

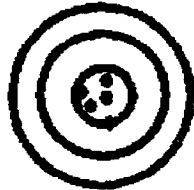
The source test observer should be familiar with the accuracy and precision of the test. A source test can be highly accurate or highly precise and still contain unacceptable levels of error if it is not both accurate and precise.

Precision is a measure of how closely the measurement results agree with the rest of the results. It asks the question: Do all the data say the same thing? Accuracy is a measure of how well the test results agree with the true value. A visual example of precision and accuracy is presented in **Figure 512.1**.

513 OBSERVING THE SOURCE TEST

Air pollution control agency personnel who may not be directly involved in the compliance source sampling process are often called upon to evaluate source tests performed by environmental consultants or companies. Since emission testing requires

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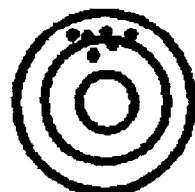
**Accurate
and
Precise**



**Neither Accurate
nor Precise**



**Accurate
but not
Precise**



**Precise
but not
Accurate**

Figure 512.1 Precision and Accuracy

that the source contract for the source test at its own expense, the source test observer should be prepared to ensure that proper procedures are followed and that representative data is obtained.

The determination of representative test data is the main purpose for the agency's observation of the test. The major emphasis to observe the test is the evaluation of the acceptability of the source test, however there are other reasons, such as establishing baseline conditions for future inspections.

Five principle areas are listed below where problems might develop in obtaining a sample that is representative of source emissions:

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- Process and control equipment must be operated in a manner that is representative of normal operation and would give emissions that are representative of normal conditions.
- The sampling port and sampling points are located so as to give samples that are representative of the emissions
- The sample collected is representative of the emissions.
- The sample recovered and analyzed is representative of the sample collected in the sampling train.
- The reported results are representative of the samples collected and analyzed.

By focusing his efforts on these five points, the source test observer's work is fairly well planned out.

513.1 THE ROLE OF THE OBSERVER

The agency observer plays a key role in during the source test program. He is the official representative of the control agency. His role includes:

- Coordinating staff availability
- Review source test protocol
- Ensure proper testing is conducted under conditions indicative of normal operation
- Observing process operations
- Observing control equipment operations
- Observing performance testing procedures and methodology
- Documenting and summarizing all activities during the testing program, especially those activities which could effect the outcome of the tests
- Reviewing the test report for completeness, accuracy, and representativeness of the test
- Auditing reported data and calculations for accuracy
- Invalidating a test on-site

In his role as official agency representative, the observer is responsible for representing the interests of the agency during all areas of the source test. The observer will, during the planning phase and in the pretest meetings, specify all agency requirements with respect to permit provisions requirements, test methodology, process and control equipment operation, and reporting requirements. The observer will review and make decisions as necessary in each of these areas where problems might occur in obtaining a sample that is representative of the source emissions:

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- Process and control equipment must be operated in a manner that is representative of normal operation and would give emissions that are representative of normal conditions.
- While observing the sampling port and sampling during on-site testing, the observer acts as a QC/QA officer and is responsible for the validity of the tests. He must make decisions as to the representativeness of process and control equipment operation and determine if acceptable testing methodology is being used. If errors or accidents occur the observer should immediately coordinate between the testing and source personnel and evaluate the impact on test validity.

Post-test responsibilities of the observer include documenting all occurrences during field testing in an observer's summary report. The observer must also review the test report for completeness, accuracy, and representativeness; and make recommendations as to the acceptability of the test report.

Although the observer is not likely a lawyer, nor is he likely a legal expert, often it is useful for the observer to consider if he feels that the tests are legally defensible. In the potentially highly contentious circumstances of a compliance test, the observer could be faced with intense scrutiny from either agency or industry legal experts. The observer should ask himself during the course of the tests: 1) can he defend the test methods, procedures, results, etc. and 2) can he cast doubt on the results due to test points located so as to give samples that are not representative of the emissions.

The observer should extensively document the source test activities; checklists are frequently useful devices to document the test.

The observer should examine the qualifications and experience of everyone conducting the test. Is the testing company and test team qualified and competent? Will the sample results be analyzed by a qualified and competent laboratory?

During the source test the observer should confirm the working calculations of the source test team. Primarily, the source test observer should refer to and be familiar with the entire method being used. The observer should also examine the test methods being used to be certain the methods are appropriate and reliable. In most tests there are at least minor modifications of the methods needed to accommodate the specific circumstances of the source. Any modifications or alternate methods must be appropriate and approved.

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The observer is acting as the official representative of the agency, and so it is the observer's responsibility to do all in his power to ensure that testing is completed properly. He must work cooperatively with the source and the testing consultant, be specific and clear in his requests, while being courteous of the positions of all parties involved.

While observing on-site testing, the observer should follow these guidelines:

- Never write on process charts and graphs in the facility.
- Never turn knobs and dials in the facility.
- Never collect data that was not agreed on in the pretest meeting without obtaining approval.
- Never touch or adjust source testing equipment.
- Never question the tester or interfere during critical times of the test. However, if questions arise, they should be asked at the first appropriate time.
- Never conceal unacceptable acts or procedures to later use as justification to reject the tests.

513.2 OBSERVATION PROCEDURES

This section discusses source test observation procedures. When observing a source test, there are both physical and procedural inspection points. Physical inspections pertain to the actual sampling equipment, the condition of the equipment, and the equipment calibration. Procedural inspection points are related to the conduct of the test such as data recording, sampling, sample recovery, sample conservation, and sample analysis procedures.

513.2.1 Physical Inspections

The Method 5 sampling train consists of many parts, each of which is important to inspect. Many parts need calibration such as the probe, thermocouple, and nozzle. Some need to be properly configured according to the specific sampling train, and can include the probe assembly with the probe, nozzle, thermocouple, and pitot tube. All parts must be in proper working order and contain no contaminants. The inspection and calibration in the previous section is a good outline to follow when performing a physical inspection of components of the sampling train.

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513.2.2 Procedural Inspections

In addition to the physical inspections of the sampling train, the observer should make sure that the test is properly conducted. The procedures observed should include the specific operations of the test method, the condition of the sample collected, the recovery and securing of the sample, and facility operation. The source test observer should also note the competence and coordination of the test team.

513.2.2.1 Leak Checks

A pre-test leak check is mandatory. A post-test leak check is mandatory. The maximum allowable leak rate is 4% of the average sampling rate or 0.00057 m³/min. If a leak is found, it is traced to its source, and the sample must be corrected or the run should be voided. This decision is dependent upon the source of the leak and its effect on the results of the test run. Performing a good pre-test leak check is a worthwhile habit to develop in order to avoid problems with the post-test leak check

513.2.2.2 Sampling Points

Performing an accurate and precise source test requires that each traverse point must be quickly located and given the proper sampling time. When moving through the traverse points, each step must be done as quickly as possible. Steps include moving the probe, initial readings at the new point, flow rate calculations, flow rate adjustments, and final readings. With an adequate number of people working, these steps can be orchestrated efficiently.

513.2.2.3 Filters

The particulate collected on the filter and the visible opacity should be consistent from run to run if the source operation is stable. Similarly, the cumulative buildup on the filter and in the acetone rinse should correlate with the visible emissions readings or transmissometer data recorded. If there is a notable difference between these values, or between each run, the observer should evaluate possible reasons for the change, and pay close attention to the next test runs.

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513.2.2.4 Facility Operating Conditions

The results reported will typically be the average of three runs under similar operating conditions, and the results should be comparable to each other. During each run, at some point in time the observer must check all facility operating conditions.

513.2.2.5 Sample Train Operation

In addition to the main duty of the observer to perform sampling run checks, other observations must still take place. These are the initial and final leak checks of the sampling train, and the initiation of each sampling run. This is good time for the observer to check for proper probe placement, assembly, and orientation in the stack. The observer can also spend any slow time checking weak points or problem areas experienced in prior sampling runs.

513.2.2.6 Sample Recovery

Sample termination and recovery of all tests should be witnessed. During the sample recovery and clean-up period, many errors can occur. Errors can be caused from loss of collected sample to possible contamination of the sample. Also at this time, the opportunity for intentional biases is great. The use of a sample recovery checklist helps to ensure that all procedures have been properly performed.

513.2.2.7 Particulate Matter Contamination

Recovery should take place in a clean area. All particulate matter must be carefully removed from the sampling train and placed in sealed, nonreactive, numbered containers. This includes any particulate matter found on the nozzle, probe, and glassware. This step minimizes the chance of invalidating test results. The samples should then be delivered to the laboratory for analysis the same day that the sample is taken. Or, the samples can be placed in a locked carrying case which should be capable of protecting them from breakage, contamination, loss, or deterioration.

513.2.2.8 Laboratory Analysis of the Sample

Errors in the laboratory analysis may originate from problems with the analyzing equipment and procedures, sample contamination, or in the documentation of the results. Usually the observer cannot be present at the lab site during sample analysis.

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If, however, the laboratory is certified, the certification program pre-checks the conditions and abilities of the lab. The observer can, if he chooses, be present at the lab during the analysis, to verify the laboratories ability to adhere to good analytical practices

513.3 OBSERVATION TIPS

The following is a collection of "Tips From an Old Source Tester" listed in U.S. EPA Air Pollution Training Institute, Compliance and Source Test Observation Course Manual.

1. Measure the stack diameter from each sampling port - not all circular stacks are round. And, not all rectangular stacks are perfectly rectangular.
2. By measuring in each port, we can often find in-stack obstructions and can check ourselves against erroneous measurements.
3. If possible, shine a flashlight across the stack and check for obstructions or irregularities.
4. If possible, with a glove on your hand, reach into the sampling port and check that the port was installed flush with the stack wall (does not extend into the flow).
5. After calculating the traverse point locations (before adding sample port nipple length), you can check your work quickly by noticing if the first and last traverse point distances added together equal the stack diameter; then if the second and next to last; then if the third and third from last; and so on.
6. "Whiteout" correction fluid used on paper has amazing properties for stack testing. It dries quickly and withstands stack heat and moisture very well. To remove from a probe or Pitot tube, simply scrape it off with your pocket knife. Various tapes and black marking pens do not hold up against stack conditions nearly as well.
7. Make sure to wipe off moisture from the outside of each impinger before weighing. Do not weigh with U-tubes connected.

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8. When the required pre-test leak-check fails, tighten the component where you think the leak is located. If the leak is not there, then the quickest way to find the leak and correct it is to start at the back of the train inlet to silica gel impinger and methodically work your way forward conducting leak-checks until the leaking component is found.

9. Instead of trying to catch the probe rinse with a glass funnel and sample container, clamp an Erlenmeyer flask outfitted with a female ball joint on the probe liner ball joint and conduct the probe rinse procedure. If the probe is short, one person can perform the rinsing and brushing.

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Experienced source testers and observers realize that there are many problems that can be encountered when source sampling to determine particulate emission rates from stationary sources. Regulatory personnel involved in observing, developing, and evaluating source testing need to be familiar with the kinds of problems that can occur, and the techniques to avoid them.

601 PROBLEM SOURCES

Source test observers must be able to recognize a problem source and deal with it appropriately. Ways that problem sources can be overcome include modifying sampling equipment, using alternate procedures, and possibly modification at the source itself. Some of the possible kinds of problem sources are discussed here. The choice of which method to use is dependent upon the nature of the sampling problem, and the characteristics of the particular source.

If source test problems are anticipated during the test protocol development, most sampling problems can be eliminated and/or their effects minimized. The failure of the source test personnel to recognize sampling problems can result in delays, wasted time, and possible invalid test results.

601.1 Problem Sampling Locations

Eccentric stacks - When sampling from eccentric stacks, the tester must plan to layout the area into equal areas. Test samples are obtained from the centroid of the area. This ensures that the samples are collected from equal areas.

Tapered stacks - Tapered stacks are defined as those having a greater than a 15° angle to one side. Sampling from a tapered stack is often measured as over-isokinetic. The particulate collected is higher near the side of the stack due to its inertial properties. Samples must be taken from proportional equal areas of the stack.

Unconfined flow - The gas flow must be confined if possible. An additional stack section could be added, or a cylindrical stack may be affixed. A stack addition, however, could significantly alter the emission rate and flow pattern.

High temperatures - In a stack with an extremely high temperature environment, many problems can arise. Hazardous, thermal expansion differences can crack the probe liner, soften glass and quartz, or even cause reactive properties in the probe liner.

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Saturated stack gas - With a saturated gas stack, impingers should not be used to determine the moisture content. The psychometric chart should be used since at saturation, the gas is holding the maximum amount of water vapor for a given temperature.

602 TROUBLESHOOTING

Table 602.1 shows symptoms, causes and corrections to be used to troubleshoot source test problems.

603 NEW TRENDS IN SOURCE TESTING

603.1 FTIR - FOURIER TRANSFORM INFRARED (FTIR) SPECTROSCOPY

FTIR CEM systems have been specifically created to meet the HAPS (Hazardous Air Pollutants) monitoring requirements of Title III of the 1990 CAAA (Clean Air Act Amendment). The DOE (Department of Energy) successfully funded the CRADA (Cooperative Research and Development Agreement) to develop an FTIR system it could use to monitor incineration of hazardous compounds at several of its facilities.

The first prototypes of this project were tested in high temperature, high moisture environments with complex mixtures of very reactive and corrosive compounds. Commercial FTIR systems have now been developed.

603.1.1 FTIR Analysis

FTIR is an analytical technique used to identify organic, and possibly, inorganic materials. The technique measures the absorption of various infrared light wavelengths by the material used. These infrared absorption bands identify specific molecular structures and components.

Most organics and many inorganics are infrared absorbers. They can be detected and quantified by FTIR methods depending on their stability and interference with other infrared absorbers.

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Table 602.1 Troubleshooting Chart

Symptom	Possible Cause	Correction
1) Loss of Pitot Tube Reading	a) Kink in Line b) Condensate in Line c) Plugged Pitot Tube d) Air Bubble in Manometer e) Dirty Manometer	Straighten Line Remove Line and Expel Condensate Blow Out Pitot Tube Remove Bubble Remove and Clean
2) Negative Pitot Tube Reading	a) Sampling Nozzle Not Parallel to Gas Flow b) Obstruction in Stack c) Pitot Tube Lines Crossed d) Control Box Not Level	Correct Position Make Appropriate Change Reverse Lines Relevel and Rezero Manometer
3) Fail to Maintain Isokinetic Sampling	a) Abnormal Loading on Filter Disk b) Moisture Saturated Filter c) Loose Connection d) Collapsed Tubing e) Defective Vacuum Pump f) Vacuum Gage Reading Erratic. g) Incorrect Nozzle Size h) Defective Dry Gas Meter i) Control Valves Incorrectly Set j) Pivot Point on Nomograph Moved k) Upset Condition in Process	Terminate Sampling and Replace Filter Terminate Sampling and Replace Filter Check for Leak and Retighten Connection Replace with Heavier Walled Tubing Replace Pump Replace Vacuum Pump or Gage Recheck Nomograph Settings and Replace with Correct Size Replace Meter Check Setting and Adjust Accordingly Recheck and Adjust Accordingly Stop Sampling, Resume Sampling After Upset Condition is Corrected.

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603.1.2 FTIR Uses

FTIR technology uses a unique spectral fingerprint for each organic and selected inorganic compound. This system monitors organics, acid gases and gaseous criteria pollutants. It is designed for compliance and environmental monitoring, and process optimization.

603.2 AUTO 5

The Graseby Anderson *Auto5 Automatic Stack Sampler* automatically performs many of Method 1-5 calculations and adjustments.

The Auto5 measures and records source temperatures and pressures, calculates sampling traverses, and automatically adjusts the isokinetic sample rate. So, field data recording and report generation are made much easier to obtain.

A microprocessor stores all operating measurements, controls set parameters, and completes required calculations with precision and reliability. When sampling is complete, all parameters, measurements and calculated isokinetic conditions are transferred to a built-in floppy disk. The disk can then be used in the office or laboratory to generate final reports, utilizing a Auto5 PC Software Package. This program can also be used to precalculate and preload sampling parameters into the controller before the actual field test begins.

The Auto5 System contains five main components: the probe, a filter (hot) box and cold box assembly, monorail suspension system, sample line, and controller. All components are completely grounded and operate at 48 volts DC with either 115 or 230 volts AC input.

The system automatically adjusts for isokinetic sample rate, calculates nozzle size, plus number and location of sample points. It automatically records flow rates, temperatures, and pressures. Other features include:

- Quick verification of isokinetic sample rate and valid test results,
- Elimination of errors caused by manual calculations, and
- Maintenance of constant sample flow rate for EPA gas sampling methodology and long-term sampling requirements.

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603.3 TEOM SERIES 700 SOURCE PARTICULATE MONITOR

The TEOM Series 7000 Source Particulate Monitor is an in-situ device that provides a direct measurement of the PM concentration in a stack. The mass transducer and its collection filter is located inside the stack, and provides results in real time. The monitor comes with a number of powerful reporting tools to distill information automatically and quickly.

The monitor is designed to provide measurement results equivalent to USEPA Methods 17 and 5 (front end), as well as ISO Method 9096 for regulatory compliance testing. The instrument's real-time mass-based results provide the information necessary for calibrating PM CEM's, on an ongoing basis or periodically. Its real-time capabilities make it ideal for process characterization and the development of predictive emissions monitoring systems.

This system is a candidate for alternative methods for USEPA Methods 17 and 5 (front end), as well as ISO Method 9096.

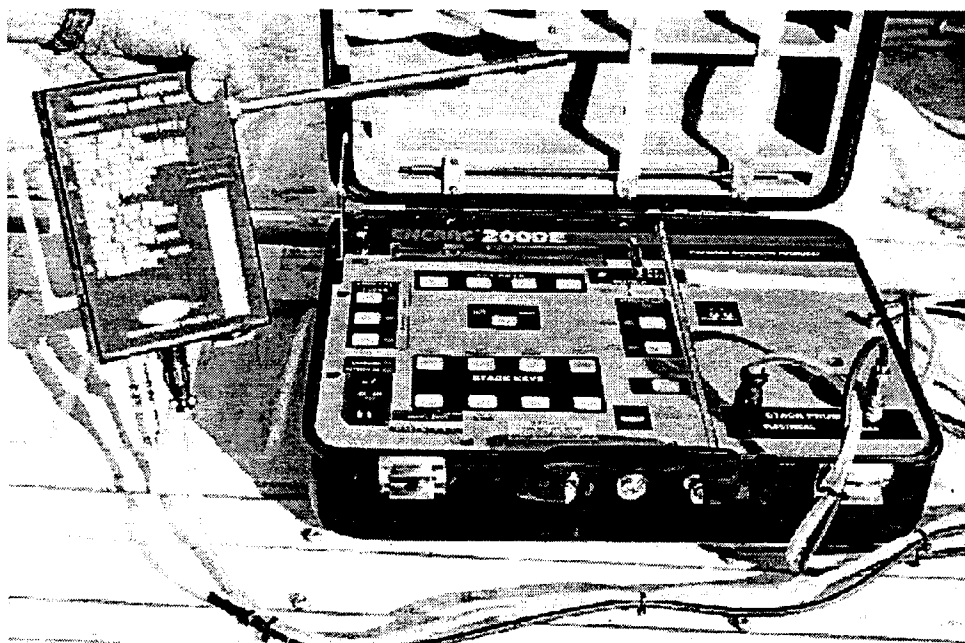


Figure 601.1 Portable Analyzer

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603.4 PORTABLE ANALYZERS

Portable emissions analyzers which utilize electrochemical cells can be quite accurate in measuring nitric oxide (NO), nitrogen dioxide (NO₂), carbon monoxide (CO), and oxygen (O₂). The calibrations remain fairly stable over time, but transient response is quite slow. Portable analyzers can be a potentially cost-effective tool for periodically measuring stationary source emission levels. It is important to make sure that the local district has approved the use of a portable analyzer before using one for a source test.

604 ADDITIONAL SOURCE TEST INFORMATION

The following list contains publication names, web sites, and reference material regarding stationary source testing:

Source Evaluation Society Newsletter

Air Resources Board - www.arb.ca.gov/

Air & Waste Management Association - [www/awma.org/links.htm](http://www.awma.org/links.htm)

Cal EPA - www.calepa.cahwnet.gov/

DOD Information Systems - web.fie.com/

Federal Register - www.access.gpo.gov/su_docs/aces/aces1140.html

U.S EPA Emission Measurement Technical Information Center (EMTIC) -
www.epa.gov/ttn/emc/

STAPPA/ALAPCO - www.erols.com/cleanair/

ACTIVE National Directory of Source Emissions Testing - www.ActiveSET.org
U.S. EPA - www.epa.gov/

U.S. EPA Region 9 - www.epa.gov.region09/

APEX Instruments - www.apexinst.com

Clean Air Engineering (CAE) - www.cleanair.com/

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GLOSSARY

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Acid rain - Rain containing nitric and sulfuric acid ($\text{pH} < 5.2$), which is formed by the combination of nitrogen and sulfur oxides with water vapor in the atmosphere.

Absorption - A substance being retained on a surface and also passing through the surface to become distributed throughout the phase.

Adsorption - The concentration of a substance on the surface of a solid or a liquid.

Atmospheric pressure - The pressure the atmosphere exerts on an object.

Auto 5 - An automatic stack sampler that performs many of Method 1-5 calculations and adjustments, records source temperatures and pressures, calculates sampling traverses, and automatically adjusts the isokinetic sample rate.

Avogadro's Principle - Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules.

Bernoulli's Principle - A general energy equation that relates kinetic energy, flow energy, and potential energy.

Boyle's Law - At constant temperature a fixed quantity of gas occupies a volume inversely proportional to the pressure exerted on it.

Calibration drift - The difference in the CEM output readings from the established reference calibration value after a stated period of operation during which no unscheduled maintenance, repair, or adjustments took place.

Charles's Law - At constant pressure, the volume occupied by a fixed mass of gas is directly proportional to the absolute temperature.

Continuous Emissions Monitoring System (CEMS) - The total equipment required for monitoring and determining a pollutant concentration, which operates continuously inside a stack or other emission source.

Compliance Assurance Monitoring (CAM) - A regulation established in response to the Clean Air Act Amendments (CAAA) of 1990 containing several provisions requiring major sources to conduct monitoring and make compliance certifications.

GLOSSARY

Dalton's Law of Partial Pressures - The total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of the various gases.

Hazardous Air Pollutant (HAP) - An air pollutant listed under section 112(b) of the Federal Clean Air Act as particularly hazardous to health.

Ideal Gas Law - An expression that relates absolute pressure, temperature, volume and number of moles of a gas.

Isokinetic sampling - An equal or uniform sampling of particles and gases in motion within the stack.

National Emission Standards for Hazardous Air Pollutants (NESHAPS) - Emissions standards set by the U.S.EPA for a hazardous air pollutant, which may cause an increase in deaths or in serious illnesses.

New Source Performance Standard (NSPS) - Uniform national EPA air emission standards that limit the amount of air pollution allowed from new sources or from modified existing sources.

ORSAT Analyzer - A device that measures %CO₂, %O₂, and %CO in a gas, using absorbing solutions to absorb CO₂, O₂ and CO from the gas.

Orifice meter - A restriction type flow meter which creates a pressure difference corresponding to the magnitude of the gas flow.

PM10 - Criteria pollutant consisting of small particles with an aerodynamic diameter less than or equal to 10 microns.

Resource Conservation and Recovery Act (RCRA) - 1976 act that governs the generation, treatment, storage and disposal of solid and hazardous wastes.

State Implementation Plan (SIP) - A plan prepared by states and submitted to U.S.EPA describing how each area will attain and maintain national ambient air quality standards.

Toxic Air Contaminant (TAC) - Substances which are determined to be carcinogenic, teratogenic, mutagenic, or otherwise toxic or injurious to humans.

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CONSTANTS

Avogadro's Number	6.02×10^{23} atoms per gram-atom
Faraday constant	9.65×10^4 Coulombs per mole
Gas Constant (R)	depends upon units of pressure, volume, moles, and temperature used

COMMON STACK GAS CONSTITUENTS

Molecule	Symbol	Molecular Weight
Oxygen	O ₂	32
Nitrogen	N ₂	28
Water	H ₂ O	18
Carbon Dioxide	CO ₂	44
Carbon Monoxide	CO	28
Sulfur Dioxide	SO ₂	64
Nitric Oxide	NO	30
Nitrogen Dioxide	NO ₂	46
Air (dry @20°C)	—	28.9
Air (saturated @20°C)	—	28.7

STANDARD CONDITIONS

International Scientific Standard Conditions

<u>Pressure</u>	<u>Temperature</u>
760mm Hg	0°C
101.3 k-Pa	273 K
29.92 in. Hg	460 R
406.79 in H ₂ O	
14.696 psia	

Stationary Source Test Observations	GLOSSARY
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EPA Stationary Source Reference Methods

Pressure

760 mmHg

29.92 in. Hg

Temperature

25°C

68°F

US Gas Industry Standard Conditions

Pressure

30.00 in.Hg

Temperature

60°F

520 R

CONVERSION EXPRESSIONS

Temperature

$K = ^\circ C + 273.15$ Kelvin

$R = ^\circ F + 459.4$ Degrees Rankine

$^\circ C = 5/9(^{\circ}F - 32)$

$^\circ F = 5/9^{\circ}C + 32$

Gas Conversion Units

To convert ppm to milligrams per cubic meter (mg/m³) at a set of standard conditions:

$$\frac{\text{mg}}{\text{dscm}} = \frac{\text{ppm} \times \text{MW}}{22.414 \times (T_{\text{std}} / 273.15)}$$

At EPA Standard Conditions:

100 ppm CO = 116 mg/m³

100 ppm HCl = 163 mg/m³

100 ppm NO₂ = 191 mg/m³

100 ppm SO₂ = 266 mg/m³

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